INFLUENCE OF URBAN GEOMETRY ON PUBLIC INVESTMENT COST OF URBAN TECHNICAL INFRASTRUCTURE: A CASE STUDY OF SEWER SYSTEM IN AYDIN, TURKEY

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Tankut GÖKÇEN

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İZMİR

We approve the thesis of **Tankut GÖKÇEN**

Date of Signature

………………………………..

Asst.Prof.Dr. Erkal SERİM Supervisor Department of City and Regional Planning İzmir Institute of Technology	**31 January 2006**

………………………………..

Assoc.Prof.Dr. Semahat ÖZDEMİR Department of City and Regional Planning İzmir Institute of Technology	**31 January 2006**

…………………………………

Asst.Prof.Dr. Nicel SAYGIN Department of City and Regional Planning İzmir Institute of Technology	**31 January 2006**

…………………………………

Asst.Prof.Dr. Yıldırım ORAL Department of City and Regional Planning Dokuz Eylül University	**31 January 2006**

…………………………………

Prof.Dr. Güneş GÜR Technical Science College Konya Selçuk University	**31 January 2006**

…………………………………

Assoc.Prof.Dr. Semahat ÖZDEMİR Head of Department İzmir Institute of Technology	**31 January 2006**

……………………………………..
Assoc.Prof.Dr. Semahat ÖZDEMİR
Head of Graduate School

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ABSTRACT

The design and implementation of urban technical infrastructure investments have been largely ignored within the traditional planning processes. This process is generally performed, first, by producing urban development plans and only then, by developing the plan for the urban technical infrastructure. While this process runs in Turkey as described above, international practices, including those in the developed countries, does not differ all too much; However, today it is very clear that the process of developing technical plans for the infrastructure, which are subject to unique design principles and criteria and are concealed underground must be handled within the site plan developing process. For the purpose of providing sustainable urban development and efficient use of limited natural resourses, integrating infrastructure considerations into city planning process and providing interrelation between them with the aim of minimizing infrastructure costs for public sector are the main goals of the research. To achieve this goal, the study is comprised of the following sections; evaluation of current city and infrastructure planning and construction process and principles to constitute an interrelation between each other by means of comparative analysis techniques; relationship between urban macro-form and urban technical infrastructure costs with respect to urban land use decision, urban net and gross density; and critical evaluation of sustainable form of urban development "compact city form" and urban technical infrastructure relationship. Finally, as a case study, Aydın (a western mid-sized city of Turkey) development plan has been examined and compared with technical infrastructure costs by means of GIS technologies. Using this method; the new development and construction typology for cities, substantive and procedural contribution to the city planning process has been described to reduce the negative side effects of traditional development process of cities for the future. Eventually, completed comparative analysis indicate that instead of improving both planning process defectiveness, location of urban technical infrastructures in alternative spaces or distinctive urban development pattern (modified hexagonal development pattern) has significant contribution on minimizing public investment cost and achieving sustainable urban development as well.

ÖZET

Doğal nüfus artışı, sanayileşme, yeni iş olanakları, toplumun sosyal ve kültürel ihtiyaçlarının karşılanması, kırsal alanlardan kentlere göçleri artırarak kentlerde birçok çevresel, ekonomik, sosyal ve teknik problemin ortaya çıkmasına neden olmuştur. Bugüne kadar sürdürülegelen kent planlarının üretim sürecinde kentsel teknik altyapı planlarının üretilmesi hep gözardı edilmiştir. Süreç, önce kent planlarının üretilmesi daha sonra oluşturulan kent planlarının altyapı ihtiyacının karşılanması şeklinde olmuştur. Bu süreç Türkiye'de böyle işlemekle beraber, yurtdışındaki uygulamalar da farklılık göstermemektedir. Toprak altına gömülen, kendine özgü tasarım prensipleri ve kriterleri olan teknik altyapı yatırımlarının, kent planlama süreci ile eşgüdüm içinde ele alınması gerekliliği yadsınamaz bir gerçek olarak önümüzde durmaktadır. Buradan hareketle sürdürülebilir gelişmenin sağlanması ve kıt olan doğal kaynakların etkin kullanımı adına, kentlerde oldukça yüksek maliyetlerle ortaya çıkan altyapı maliyetlerinin minimuma indirilmesi, kent planlama sürecine altyapı planlarının üretim sürecinin entegre edilerek eşgüdüm içinde planlanması bu araştırmanın temel konusunu oluşturmaktadır.

Sürdürülebilir kentsel gelişmenin sağlanabilmesi amacı ile kent formu ile altyapı maliyeti ilişkisinin--kentsel arazi kullanış kararları, bunların net ve brüt kullanım yoğunlukları ve üçüncü boyuttaki yapılaşma biçimi ile--ortaya konulması, geleceğe dair alternatif yaşam çevrelerinin oluşturulmasında(zeminaltı mekân kullanımı ile) planlama sürecinin bu kapsamda yeniden irdelenmesi ve yeni kent formu yaratmadaki yaklaşımların özellikle "compact" kent formu kavramının irdelenerek altyapı maliyeti açısından avantaj ve dezavantajlarının ortaya konulması ise tüm çalışmayı şekillendirmiştir.

Yapılan çalışma, orta ölçekli bir yerleşme olan Aydın kenti üzerinde geleceğe dair geliştirilen alternatif senaryoların kentsel teknik altyapı maliyetleri açısından CBS (Coğrafi Bilgi Sistemleri) teknolojileri kullanımı ile karşılaştırılmasını kapsamaktadır. Böylelikle artan nüfus ile her geçen gün sınırları genişleyen kentler için geleceğe dair yeni bir yapılanma biçimi tarif edilmiş olacaktır.

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CHAPTER 1

INTRODUCTION

According to the results of the year 2000 population census, in Turkey the entire population is 67.844.903 and 44.109.336 of this figure living in cities. While the ratio of the total population growth was declared to be 18.34 % for the years 1990-2000, this ratio is 27.04 % and 3.95 % in cities and rural areas respectively (WEB_1 2005). These numbers show that the ratio of population growth in cities is approximately 9 points above the average growth in general. This high ratio of population growth in cities brings about many problems in cities. Besides this increase in population; acceleration in industrialization, new and expanding employment opportunities have modified the quality of life in cities and caused migration from rural to urban areas, which in turn has given rise to numerous environmental, social, economic and technical problems (Turabi 1988). Dramatic immigration from rural areas to cities first causes squatter areas within the cities. The quality of life in cities started to decrease. Deterioration in today's cities has a lot of consequences; such as, increasing traffic jams, noise, air pollution, lack of green and recreational areas, and the insufficiency of the urban technical infrastructures for technical, social and cultural activities (Ray 1998). Most of the time, these problems reach uncontrollable level and eventually the deterioration of environmental quality keeping citizens from living in comfort and also sometimes threatening their health (Durmisevic 1999).

This global problematic growth in cities reaches to extend that it might be alarming environmentally and ecologically. As a result of global warming and thus the ecological imbalance, the magnetic shield weakness of the earth and radiation storms cause serious alarming results and additionally according to some scenarios northern part of the world is going under ice age once again. Eventually all these kind of signs emphasize the importance of sustainable development pattern of cities. For the purpose of this kind of development pattern, creating alternative built environments for changing circumstances to the future should be the main focus of future works.

Eliminating or minimizing the negative side effects of non-user friendly living environments, increasing the quality of life and forming healthy living environments, the cleaning up of the bad impacts of environmental deterioration are only a few of the problems still currently valid and waiting to be resolved. What solutions to these problems to be offered and what methodologies to be developed are all analyzed by the administrators of cities and the project managers. The alternatives offered for the problems are approaches such as reshaping the city spaces and resolving or reformulating the current problems, however they still seem to be inefficient to offer radical solutions.

1.1. Definition of the Problem

Cities changing and developing everyday, the embedded technical infrastructure, which is supporting and complementary part of the superstructure, loses its sufficiency and efficiency causing greater problems than the ones already exist. Infrastructure problem is actually an important kind of threat for human health. Providing urban technical infrastructure that people needs to survive in healthy living environment is still problematic because of the inadequacies of the coordination network of financial, constructional, managerial and maintenance levels of the projects.

Preparation, construction and management of the urban technical infrastructure projects require great amount of money. For this reason the economic and efficient operation of the infrastructure system should be an important part of the economic precautions due to reducing the negative side effects of recent economic crisis in Turkey. For the proper use of resources, location of the urban settlement should be properly determined and then according to the land use decisions of settlements the technical infrastructure of the city should be sufficiently detailed and projected. Limited economic resource availability, inadequate use of resources, project defectiveness, the lack of qualified staff members, revisions of the development plans of cities, uncontrolled development of slum areas and the increase in density bring about the demand of increasingly large populations of people simultaneously willing to take advantage of the city's technical services, which in turn cause shortening the economic life of the investments of infrastructure systems that requires new investment decisions.

On the one hand, the increased traffic congestion, pedestrianization work and new public transportation modes and routes; on the other hand, variety occurring day by day due to technological developments and continuous construction, renovation and maintenance works of some parts of these routes create great stress on insufficient urban traffic routes. Questioning and determining the purpose of the use of these traffic routes, location of urban technical infrastructure in subsurface area of these spaces and searching for alternative location for them are today still on active debate as cost-effective approach in terms of alternative solutions. The focus of the debate is the necessity to clearly determine the main purposes of using these spaces, because the topic in discussion is arising as a dilemma and this dilemma can be explained as follows:

What is the main function of the urban traffic routes? Is it a corridor or surface area on top of which transportation of people, properties, and services take place or is it a quite complicated space where cables, pipes and tunnels place themselves for the energy transmission and connection routes of clean water, waste water drainage sewage and communication? (Marvin and Slater 1997).

Or else, is there definitely no need for such a dilemma? Since today the use of internal city roads serving simultaneously both of the purposes mentioned above might be the most effective and economic form of use.

As a starting point, finding out the exact function of the urban traffic and pedestrian routes may lead to decide whether the solution should be searched in these spaces or not. After that point, manipulation of these spaces or alternative location of these services should be selected as a problem solving technique for the purpose of minimizing cost of urban technical infrastructures.

Current implementation on infrastructure system of cities generally have technical, economic or engineering point of view, however, they unfortunately ignore social, economic and political relationship between the cities and their technical infrastructure structures. The unique technical requirements and necessities of urban infrastructures forced these services to be embedded under the limited space of pedestrian and traffic roads, which in turn brought about construction and maintenance problems. So, because of the developing technology and increasing variety of services, new additional services desperately search for a place next to existing services within the limited transverse road line. Moreover, embedding these investments underground demanded high costs during the construction and maintenance stages, existing problems encouraged to be solved by new approaches and techniques. In England, if these embedded services are added to one another, their total length is enough to circle the perimeter of the world 45 times and with the costs indexed to 1983, 1650 sterling (1 sterling =1.73$) cost is calculated for each house (only the parcel related cost equation) and with a total cost of 27 billion sterling in general. It is declared that 80% of any infrastructure usage is embedded underground, and an average of 1 billion sterling is only used for excavation and renewal processes. It is also added that every year 18.000 km infrastructure investment is made (Marvin and Slater 1997). During the period of 1996-2000 in Turkey, the investments made by the İller Bank carried out 33% of sewage and 56% of clean water work. According to the unit prize of 2000, during this period 367.308.698.YTL (681.721.278 $) and 617.014.036 YTL (1.145.171.894 $) was spent on sewage works and clean water works, respectively (Iller Bank annual report 2000). In addition to these economic costs, calculated social costs during these works caused by delay on traffic, environmental contamination, high level of risk of pedestrians and vehicles faced with is approximately 15 billion sterling a year. The effects on the human health and living standards, demolition of green areas and limiting the movement ability of handicapped should be added all type of social costs mentioned above (Marvin and Slater 1997).

Traditional planning process directs the development of the cities and its parts with respect to land use and density decisions and transportation network. However, so far the suitability analysis of infrastructure investments with land use decisions, the cost of physical infrastructure investments that land use decisions need for existing areas and the development areas and also their additional cost on top of the total cost have been ignored and even not taken into consideration. Similarly, the technical infrastructure services designed for city development plans have been projected as an engineering works that mutually disregard their design principles and standards. Decisions concerning infrastructures are made generally without any relevancy of urban development plan decisions and therefore they lose their sufficiency in time. As a result of this kind of an approach, the construction and maintenance costs of urban technical infrastructures increase naturally. Besides the reasons mentioned above, unplanned and uncontrolled development of the cities has also an important role in this process. While ecological and sustainable planning are popular concepts in current planning literature, new development pattern within the existing settlement area or outskirts of cities turn into a process which underestimates of existing structure and capacity of technical infrastructure. As well, upgrade of existing infrastructure structure without any efficiency assessment lead to inefficient use of limited natural resources.

High cost of construction and management of the urban technical infrastructure projects, inadequacies of the coordination network of financial, constructional, managerial and maintenance levels of the projects, revisions of the development plans of cities, uncontrolled development of slum areas and the increase in density bring about serious problems on existing infrastructure investments. This problematic circumstance urgently requires a fresh look at both current physical and infrastructure planning process.

1.2. Scope and Aim of the Study

In general, plan production process of service utilities and urban development plans are performed and conducted separately. General approach for production process of infrastructure plan is superimposing projected infrastructure plans on the city plan usually under the roadways. Additionally, while forming the planning and construction rules and regulations, this approach is visibly accepted by governmental institutions as an engineering application. Such kind of production process, which mutually overlooks the design and construction principles, increases the regular cost of infrastructure investments. Therefore, integrating and overlapping both processes for minimizing the public infrastructure investment cost is the main concern of the thesis. As configuring the goals and objectives, tools and means to solve the problems that the thesis described, general structure of the thesis constructed for minimizing urban technical infrastructure public investment cost. As a public investment cost it is imply that total infrastructure costs that locate under the public space such as; urban traffic routes or alternative public spaces within the urban settlement. While minimizing total cost of infrastructure elements, creating sustainable urban development by minimizing consumption of natural resources, minimizing production of waste, minimizing pollution of air, soil and waters and increasing the proportion of natural areas and biodiversity in cities would be achieved as a secondary purpose of the thesis as well.

To match the urban settlement's total needs of urban technical infrastructure, the structure of service utilities should be clearly described.

1. Macro-scale Supporting Infrastructure Elements of Urban Settlement; Transportation Routes, Water supply and storage, High-tension electricity line and transformation area, Gas production and support.

2. Network Structure of the Service Utilities within Urban Settlement; Transportation network, Water distribution network, Electricity distribution network and local transformation areas, Telecommunication distribution network, Gas distribution network, Central heating network, Storm-water drainage network, Waste collection.

3. Removal Facilities of Waste from Settlement; Sewerage treatment plant, Waste disposal plant.

As described above, general structure of the urban technical infrastructure elements consists of macro-scale supporting infrastructure elements, networked structure of the service utilities within urban settlement and removal facilities of waste from the settlement. Defined as a necessity and prerequisite, to be able to perform the urban social, economic and cultural life, to give a direction to urban land development and to be able to live in healthier living environment after development stages and classified as;

1.*Technical Infrastructure;* (Roads, Drainage and Sewage water canals, Water, Electricity, Telephone, Gas, Communication, Central heating equipments, etc.)

2.*Social-cultural Infrastructure;* (administration, security, service, education, culture, religion, entertainment buildings and green areas)

3.*Private Infrastructure;* (production devices, production-oriented activity of the public, business, etc.)

forms the whole city's infrastructure (Evren 2000). Among the complete list of infrastructure elements that described above, networked structure of the service utilities within urban settlement and their relationship with public investment cost has been investigated during the study in detail. Additionally, in stages of urban macro-form analysis and integration of infrastructure planning process to the planning process just sewage system and its construction stages are studied technically in detail.

Deciding the topic of the thesis and giving a direction to main body of it "European Sustainable Cities Report-1996" prepared by European Union the Expert Group on the Urban Environment is evaluated and accepted as a starting point; because of its problem formulations, principles for resolutions and policy options overlapped with the thesis approach and addressed the similar probable solutions such as; *"Compact Urban Form" "Smart Growth"* about urban macro-form alternatives. The Expert Group launched the Sustainable Cities Project focusing on sustainable urban development and the integration of environmental objectives into planning and management strategies and the main output of the project, the European Sustainable Cities Report, is concerned with identifying the principles of sustainable development and the mechanisms needed to pursue it, not only in cities, but at all levels of the urban settlement hierarchy. The report also provides a framework for local action and identifies a set of principles to use in setting goals and in evaluating and monitoring progress towards sustainability in urban areas.

Although it has been emphasized many time that infrastructure has direct effect on superstructures and should be handled with corresponded approach with it, there is no suggestion of a concrete example and discourse to shape, describe and direct the physical planning structure. In Turkey, academic researches on infrastructure generally focus on management and finance of public sector infrastructure projects (Akkiraz 1998) or cost analysis and problem evaluation of mass housing and squatter areas' infrastructure investments (Unutmaz 1994; Konuşkan 1989). Research by Erdin (2001) performed a threshold analysis of water and sanitary projects of İzmir. Population projection and total water supply relationship (Erdemli 1999) and comparative analysis of infrastructure investment construction and type of finance and payment relation also analyzed as a PhD and Master thesis topic in detail (Turabi 1998). Apart from works on infrastructure in Turkey, with respect to sustainable development and minimizing infrastructure investment cost, international researches and their contribution to global knowledge is significant and at some point overlap with my thesis topic. While the international works in the area of minimizing the infrastructure costs are generally focus on; developed models based on the threshold and capacity analyses of infrastructure elements in existing urban settlements (Bierman 1999), rehabilitation and effective usage of infrastructure investments to achieve sustainable development (Siddiqui 1997), control of urban growth by using infrastructure pricing and timing models and defining urban growth boundary to achieve efficiency in the utilization of infrastructure for local authorities (Ding 1996), relationship between under-priced infrastructure and urban development patterns to define more resource efficient development pattern, this study aims to define a new approach to Turkish physical planning process by perform an analysis of current "*Model Building by-law*" and its standards for residential development areas and describe future development patterns that include alternative location of service utilities for minimizing the public investment costs of infrastructure. Different from international works on infrastructure, the study focus on future residential development areas that described with *"Model Building by-law"*. Therefore, except for existing residential areas, general evaluation and examination of infrastructure cost of future residential development areas are evaluated and examined with this study.

Providing more efficient use of technical infrastructures and improving quality of life properly can only be achieved by integrating or overlapping the production processes of both of the plans. By doing this, a technical, organizational and procedural structure of physical planning process provide for shaping healthier living environments, minimizing the infrastructure costs and efficient use of limited resources. By analogy, if cities are considered as human bodies, the need to study more anatomy is obvious (Bexter 1995). According to some views providing sustainable infrastructure can only be acquired by little adjustments on existing structure of the process, according to others, new systems with new principles should be constructed (Balslev and Elle 2000). Considering the high economic, environmental and social costs of the infrastructure system it is clearly stated that for the purpose of efficient use of limited natural resources, the resolution of construction, maintenance and management problems of urban technical infrastructure is bound to the concept of urban planning. If the process of the technical infrastructure planning could be achieved by designing and constructing the whole service facilities in the holistic approach, cost and time saving and efficient problem solutions that inherent in underground facilities would be accomplished. By doing this, sharing information, communication, counseling, coordination between concerned governmental institutions during the project stage would help to create healthy and modern built environment of cities. The interdisciplinary structure of the planning process unquestionably asks for such an approach. Additionally, the orderly placement of the technical services underground space and having underground plans of them would allow the repair and maintenance process without any damage to the other parts of the systems.

1.3. Methodology

The thesis begins with inquiring the relationship of cities' technical infrastructure and its macro-form alternatives. Does minimizing the infrastructure costs depend on the diagnostic of the macro-form of the city such as; land use pattern together with density decisions and consequently type of building? In other words, will the minimization of the total cost of the whole infrastructure elements embedded under the traffic routes be provided by a decrease in the total length of all roads across the city? Therefore, as indicated in the title of the thesis, influence of urban geometry that describe with *"Model Building by-law"* on total infrastructure investment cost has been investigated in detail. Instead of using "urban form" in the title of the thesis, urban geometry has been preferred because of its 2-Dimentional spatial layout implications. In chapter 3, mainly 2-Dimentional spatial layout with its 3-Dimentional alternatives for different density decisions of urban settlements that described with *"Model Building by-law"* examined for reducing total infrastructure costs.

For the purpose of integrating and overlapping planning processes (Infrastructure and City planning process), macro-scale and micro-scale alternative resolutions to the cities offered and examined in detail. As a macro-scale approach, procedural and substantive contributions;

1. Examining the relationship between macro-form of the city and total infrastructure investment cost.

- Assessing the effect of land use structure, density distribution and type of buildings of the city on infrastructure public investment cost. (Evaluation of *"Model Building by-law")*

- Relationship between, building type, coverage area of the city and total road length. (Comparison of building blocks' cost of infrastructure with different density)

- Evaluation of alternative transportation network of the city (hexagonal development pattern for residential neighborhood design.)

2. Sustainable urban development: "Compact City Form"

- Advantages and disadvantages of compact urban form

- Multi-layered Urban Land use (using underground space)

- Evaluation of land ownership laws in terms of construction in Turkey and in foreign countries.

3. Evaluating and comparative analysis of current city and infrastructure planning and construction principles to constitute an interrelation between each other with respect to; location, technical analysis of land survey, (Slope, land type, watershed, fault line...), construction.

4. Find out and combine the overlooked or missing points, which are crucial and frequently used for both existing planning and construction stages to constitute a reviewed and innovative model of planning process. (Comparative analysis of İller Bank infrastructure and development plan production regulations and procedure)

As a micro-scale approach substantive contributions;

1. Searching for alternative location of infrastructure elements within urban fabric.

(TSE evaluation and common trench)

2. Creating sub-district on entire network area of the city for infrastructure elements.

(Localization and grouping solutions)

3. Demand-side management of using infrastructure

4. Constitute an Infrastructure Coordination Center within the organization of municipality.

proposed and comparative statistical analysis performed to find out the most efficient solution for infrastructure investments.

In the first place, the building blocks formed with different type of buildings that is described with ("*Model Building by-law*",*Tip İmar Yönetmeliği*) with various numbers of dwellings from10 to 400 are comparatively analyzed in terms of varying value of the total construction area, perimeter and total road length. First, a comparison performed with number of units based on 10 dwellings then, between types of buildings based on detached type of housing. Secondly, previous examination, explained above, carried out again for residential neighborhood which contains 2800 residential units.

For the purpose of finding out the crucial role of how the basic principles and standards of the infrastructure implementations that is used by civil engineers form an urban macro-form and direction of urban development and also how construction and maintenance costs can be minimized by physical planning are discussed by analyzing the both plan production and construction process. As a result, at which stage each planning process should be integrated or by doing this if there is any benefit for public sector to minimize urban technical services construction and maintenance cost are interrogated. Finally, making substantial contributions to the planning process to minimize public infrastructure investment cost with respect to urban technical infrastructure construction principles, sustainable urban development that described with the European Sustainable Cities Report (1996) would be achieved as well. With the integrated or inclusive handling of physical infrastructure of cities, during the city planning process provide for;

1. Describing sustainable urban development process for the purpose of efficient use of limited natural resources, waste and energy.

2. Forming the technical infrastructure design criteria for guiding the planning process to decide density, land use and transportation decisions during the urban macro-form constitution process,

3. Investigation of various urban macro-forms because of the network structure of technical infrastructure to determine the most efficient form of urban settlement

which provide minimum public investment costs of infrastructures during the design, construction and operation stages,

4. Forming the institutional coordination required for the proper processing of the necessary construction, operation and maintenance work, or the description of a new technical and institutional organization that is responsible for the production of technical infrastructure plans.

Determining the minimization of public infrastructure costs, the sustainable development form of cities *"compact city form"* and *"use of underground space"* and *"multi-layered land-use development"* concepts have been considered as a means and tools to create future development pattern of urban settlements. Advantages and disadvantages of "compact city form" and "use of underground space use" are discussed with their all aspects.

Searching for alternative spaces for urban technical infrastructure to reduce total investment cost for public sector, *"hexagonal development pattern"* to reduce total length of traffic routes and total infrastructure length of urban settlement area compared with traditional development pattern. Urban technical services taking place in these determined alternative spaces could save a considerable amount of costs. Compared to traditional development pattern with respect to cost saving and layout considerations, *"hexagonal development pattern"* has enormous advantages. Although its advantages outweigh, in terms of traffic consideration, this development pattern needs some modification to get rid of circulation and accessibility problems. Proposed development pattern with this thesis is a kind of layout that benefits from advantages of hexagonal and traditional gridiron layout.

However, even this study results in helpful solutions to the existing problems, the stage involving the application of these results requires the decision makers, authorities, and especially the ones having authority in different technical subjects and areas to work together in coherence with an enthusiasm to share their capabilities and authorities. Moreover, since this cooperation firstly needs the overlapping of the annual investment plans of different administrative authorities, this study merely contribute technically to the solutions of the existing problems.

CHAPTER 2

DESIGN AND CONSTRUCTION STANDARDS FOR UTILITY LOCATION IN THE RIGHT-OF-WAY

In order to reduce investment cost of urban infrastructure for public sector, design standards and guidelines, construction principles and general characteristics of all infrastructure elements that furnished under the road surface area should be investigated and evaluated. Because, of every part of infrastructure elements that concealed in a limited space, has different and unique design principles and each construction requirement of service utilities might affect physical planning process differently.

All urban infrastructure elements is categorized basically as; technical infrastructure, social-cultural infrastructure, private infrastructure. Additionally, all urban technical infrastructure elements can be sort out principally in three groups. First, Macro-scale supporting infrastructure elements of urban settlements (Transportation (Highways), Water supply and storage, High-tension electricity line and transformation area, Gas production and support), second, networked service utilities within urban settlement (Transportation network, Water distribution network, Electricity distribution network and local transformation areas, Telecommunication distribution network, Gas distribution network, Central heating network, Storm-water drainage network and Waste collection) and finally removal facilities of wastes from settlement (Sewerage treatment plant, Waste disposal plant). All utilities should be located in the Right of Way (R.O.W.) at all locations that are planned for future tie-ins. All manhole lids, utility access covers and range box access covers should be located 0.65 cm to 1.25 cm below the adjacent finished street surface.

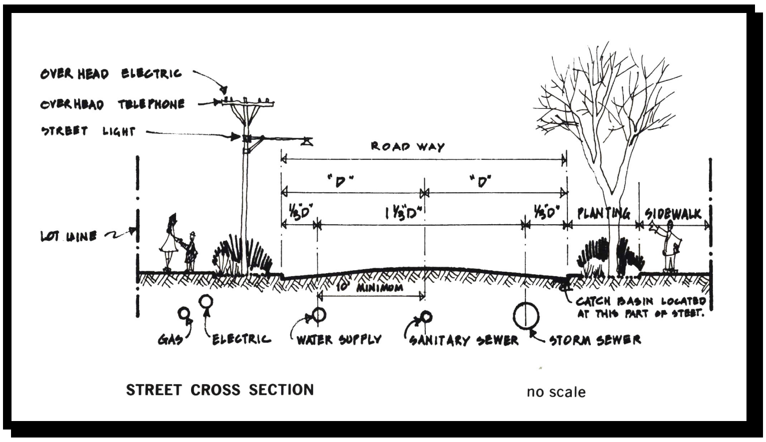


Figure 2.1 General Location of Utilities on Street Cross Section
(Source: Chiara 1969, p.294)

Although general approach to locate these technical elements is installing them under urban traffic routes, rightly they all should be located under footways or verges wherever possible rather than carriageways;

- *"so that traffic will not be disrupted during emergency repairs, routine maintenance or provision of additional services; and*

- because footways and verges over services can be constructed in materials which facilitate taking up and relaying and are less likely to suffer damage. The use of small scale units rather than in-situ paving also makes it easier to fit in access boxes and markers." (Mc Cluskey 1979, p.295).

Sanitary sewer; generally located on the center line of the roads. If it was located in the planting strip the roots of the trees might cause breaks in the pipeline. Sewer can not be grouped with the other services and generally have to be given priority of position as they form part of a far less flexible system. Properly constructed sewers rarely require repairs but with very wide roads or where it is foreseen that many branch connections will be required after the construction of the carriage way it is sometimes possible to duplicate the sewer if there is enough footway or verge space available.

Storm Sewer; generally located the distance from curb line to center line of street. It is always located on the opposite side of the street from the water line.

Water supply; may be located under sidewalk, in planting strip or under street. Minimum design requirements will locate it at least 3.00 m from nearest sewer or gas main and above highest sewer or gas main. Access is indeterminate and is required for repair and fixing new branches. Easily removable paving is desirable over water mains and at least 1.20 m diameter clear space above ground should be left around stopcocks.

Gas; generally located under sidewalk or in planting strip. Gas mains shall be located either within the right-of-way or in an adjacent easement on the South and West sides of the street or 0.90 m side of centerline adequate utility separation. Mains should be laid 60 cm to 75 cm deep; service pipes 45 cm to 60 cm. Access is rarely required to pipes throughout their lifetime. Access is usually required only to valves or to pumping pipes to remove condensate. Covers are usually 25 cm X 25 cm (Larimer County Road Standards 2000).

Electricity; Best located in underground conduit. Sometimes located in overhead lines over planting strips. This causes interferences with trees, danger of falling wires, and unsightly appearance. Generally, power and telephone lines shall be located in the North and East sides of the street either within the right-of-way or in an adjacent easement. Low voltage cables should be at a minimum depth of 45 cm below the pavement surface Underground link disconnecting boxes are required at intervals on the low voltage system, usually at street intersections with a pavement cover 75 cmX60 cm. Runs of low voltage cables are usually restricted to 120 m lengths as it is wasteful on long runs (Chiara 1969).

Telephone: Distance between jointing chambers should not exceed 150 m. The min. depth for protected cable is 20 cm; for steel ducts 35 cm and for self -aligning ducts 35 cm for one way and 45 cm for multiple-way ducts when beneath a footway, and 60 cm in each case beneath carriageway. Cover sizes range from 25cm X 70 cm to 2.30 m X 70 cm (Mc Cluskey 1979).

Additional Structures**:** Poles, signs and any other above-ground streetscape (except regulatory signs) shall be generally located within 1.5 m of the right-of-way line or 3.00 m from the travel lane (flow line), whichever is most restrictive. Light poles may be placed a minimum of 0.50 m behind a vertical curb line, or 0.50 m behind the sidewalk for attached sidewalk (Larimer County Road Standards 2000).

In a technical drawing, certain location of them under road surfaces is given below.

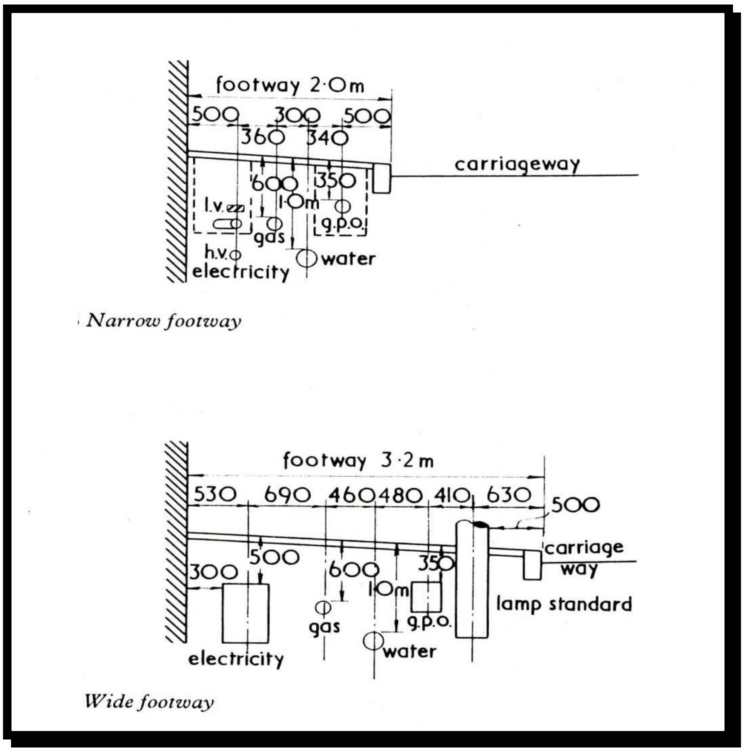


Figure 2.2 Proposed Cross-section of Footways
(Source:Mc Cluskey 1979, p.295)

Except in very low densities developments the distribution of service mains is often duplicated so that connections do not have to be made across the carriage way. The Joint Committee on the Location of Underground Services has recommended a width of not less than 3.00 m on both sides of a road, to allow distribution and service mains to be laid out in a orderly way, and allowing enough room for link disconnecting boxes and jointing pits in the electricity and the telephone system, and for valves and hydrants in the water system and for siphon pipes in the gas system. It also gives a reasonable space within which one utility can excavate and work without interference with others. If the footway is wider than 3.00 m the arrangement of wide footway should still be used in case of future road widening. Moderately sized services can be accommodated in a width of 2.00 m (Cluskey 1979).

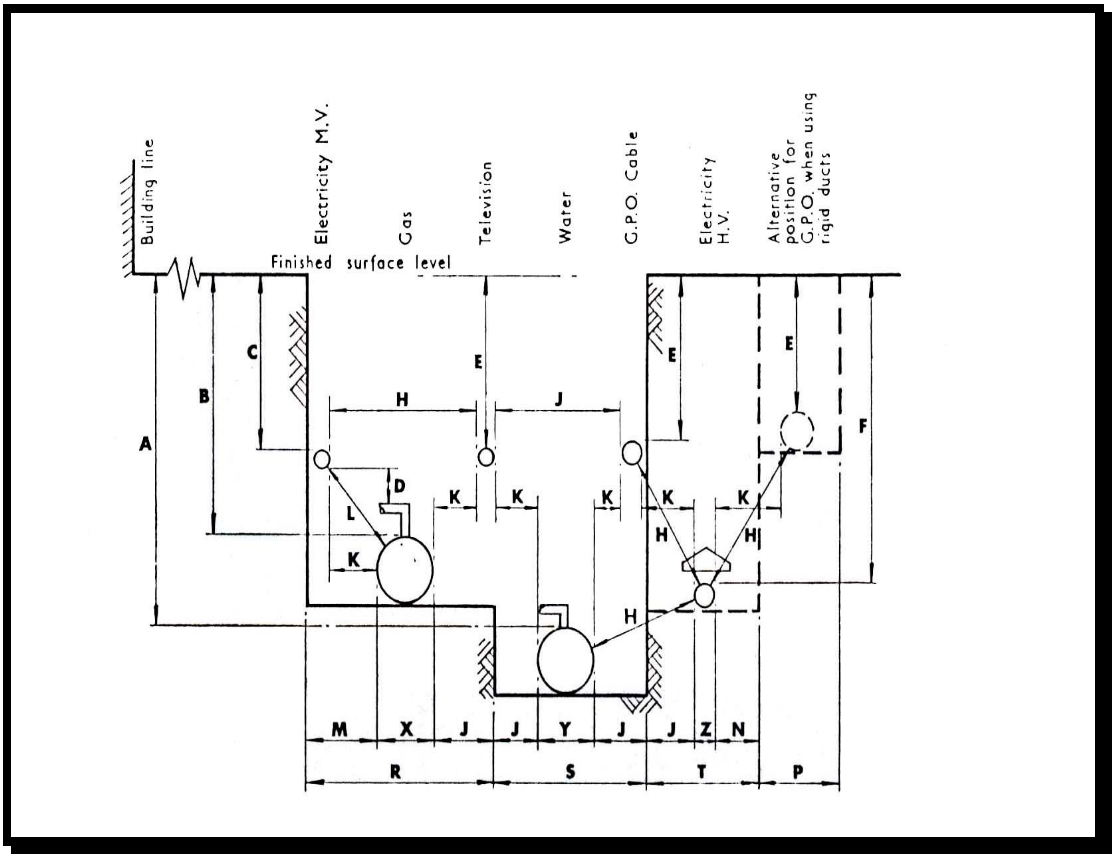


Figure 2.3 Proposed cross-section of a joint trench for housing estate distribution

(Source: Mc Cluskey 1979, p.296)

Table 2.1 Proposed Cross-section of joint trench for housing estate distribution mains (Source: Mc Cluskey 1979, p.296)

LETTER	Dimension	Remarks
A	90cm min	-
B	60cm min	-
C	45cm min	-
D	15cm min	without additional Insulation
E	35cm min	-
F	75cm	Distance of HV Cable from GPO
H	30cm min.	refers to multicore cable only.
J	15cm min	GPO require clearance 45 cm from single Core HV Cable
K	10 cm	from single core HV cable
L	20cm	-
M	25cm	when MV included, otherwise min 15cm
N	15cm	-
P	25cm	-
X	Variable	Gas pipe outside diameter
Y	Variable	Water pipe outside diameter
Z	Variable	HV pipe outside diameter

R = M + X + J

S = 2J + Y

T = J + N + Z

2.1. Location Standards and Space Requirements of Infrastructure Elements under the Roadways and Sidewalks in Turkey

According to location standards of TS 1097 dated 1975 all service utilities must comply with its requirements during construction stage. For each infrastructure elements design standards summarized below.

2.1.1. Electricity Lines:

Location: Under sidewalks

Distance from the outside border line of the Sidewalk: 0.40 m.

Width of channel: 0.80 m.

Depth of channel: 1.00 m. Upper side of the cables and sidewalk surface distance should be min.0.70 m.

2.1.2. Gas Lines:

Location: Under sidewalks. If sidewalk width less than 1.50 m, it should be located under roadways.

Distance from the outside border line of the Sidewalk: 1.15 m. If it is located under roadways distance from border line should be 1.10 m.

Width of channel: 0.70 m.

Depth of channel: 1.00 m.

Main Distributor Pipes should be located under roadways and any side of transverse road line 1.00 m in depth.

2.1.3. Water Supply Pipes:

Location: Under sidewalks. If sidewalk width less than 1.50 m, it should be located under roadways.

Distance from the outside border line of the Sidewalk: If sidewalk width is up to 2.75 and 5.00, distance should be 1.70 m and 1.85 m, respectively. If it is located under roadways distance from border line should be 1.10 m.

Width of channel: 0.75 m.

Depth of channel: 1.00 m.

Main Distributor Pipes should be located under roadways and other side of gas lines 1.00 m in depth and 1.50 m in width.

2.1.4. Telecommunication Lines:

Location: Under sidewalks.

Distance from the outside border line of the Sidewalk: If sidewalk width is up to 2.25, 2.75, 4.75 and 5.00 m, distance should be 0.40, 1.95, 2.60 and 3.50 m, respectively.

Width of channel: 0.85 m.

Depth of channel: 0.95 m. Upper side of the cables and sidewalk surface distance should be min.0.50 m.

2.1.5. Sewerage Pipes:

2.1.5.1. Combined system

Location: Under Roadways

Distance from the outside border line of the Sidewalk: If roadways width wider than 5.50m and more it should be located under roadways and midpoint of transverse road line.

Width of channel: 1.20 m-1.50 m

Depth of channel: 1.50 m

If sidewalk width wider than 10 m, it should be located under sidewalks.

2.1.5.2. Separate System

Storm Water Pipes:

Location: under roadways

Distance from the outside border line of the Sidewalk:

Width of channel: 1.20 m

Depth of channel: 1.00 m

Sewerage Pipes:

Location: under roadways

Distance from the outside border line of the Sidewalk:

Width of channel: 1.20-1.50 m

Depth of channel: 1.50 m

Above ground utilities: lighting and signage fixtures, site furniture and vegetation elements should be located 0.50 m apart from borderline of the roadway. They have to be located on wider than 1.75 m sidewalk width. The distance between borderline of the sidewalk and axes of the trees should be min. 0.75 m.

Minimum sidewalk width according to number of underground utilities:

Number of Utilities	Width of Sidewalks
1	2.75 m
2	3.50 *(4.25)*
3	4.00 *(4.75)*
4	5.50 m

(Italic Figures indicate that one of the utilities is gas line.)

2.2. Evaluation of TS1097

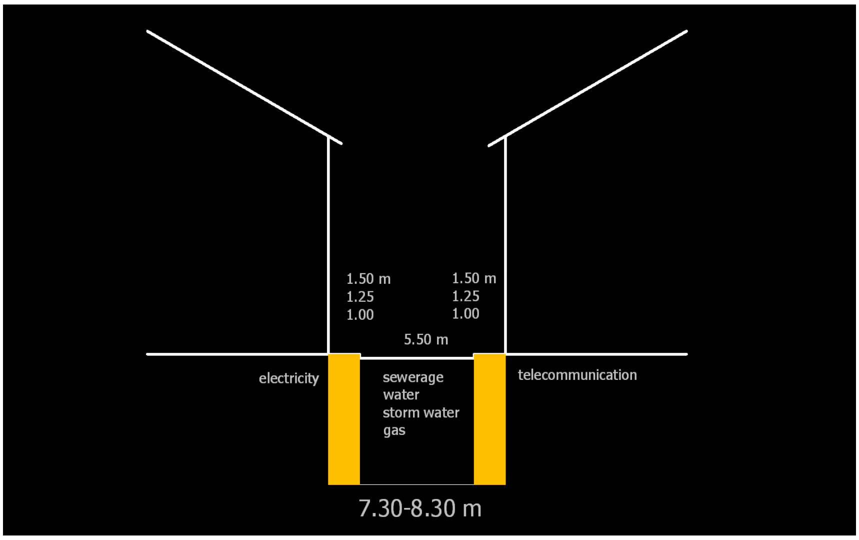
Every infrastructure elements require specific land coverage for both side of the roadways both in depth and width. Certain distance between them shape the total road width. (See figure 2.1 and figure 2.2) In fact, different road width contains limited number of infrastructure elements. As road width especially sidewalk width getting wider, number of infrastructure elements increase.

Width of Roadway	**Location of Infrastructure Elements**
7.30-8.30 m	1.Electricity and telecommunication inf. locate under sidewalks. 2.Sewerage, water, storm water and gas locate under roadways.
9.00-9.30 m	1.Electricity, gas, telecommunication, and water supply locates under sidewalks. 2.Sewerage and storm water locate under roadways.

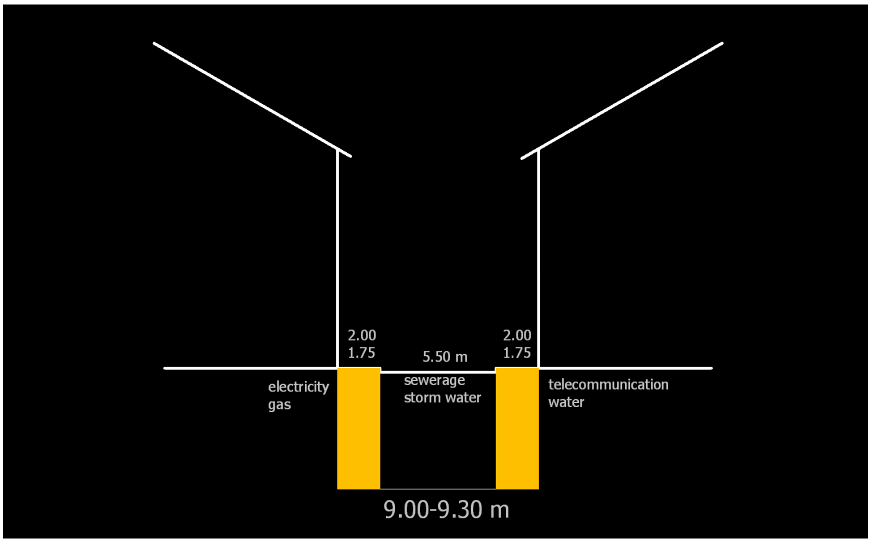
9.30 m critical road width; because every infrastructure elements locate under roadways once. As sidewalk width become wider, certain infrastructure elements choose a place for both side of the roadway.

10.00-11.00 m	1.All infrastructure elements except for sewerage and storm water locate under sidewalks and number of utilities under sidewalk keeps in 3.
11.50-15.50 m	1.Both side of the sidewalk contain all infrastructure elements. 2.Main water and gas pipes, sewerage and storm water pipes locate under roadways.

11.50 m road width also critic, because all infrastructure elements locate both side of the roadway. Main water and gas pipes locate under roadways.



Group I



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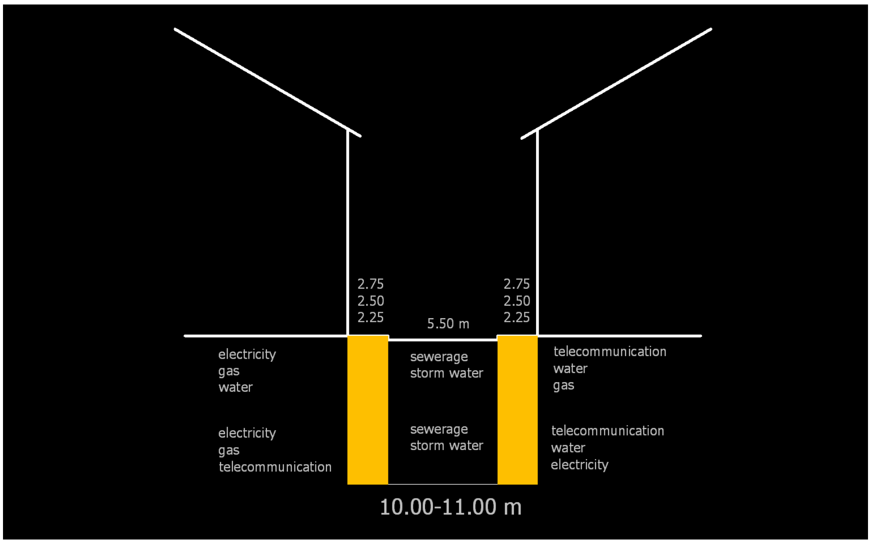
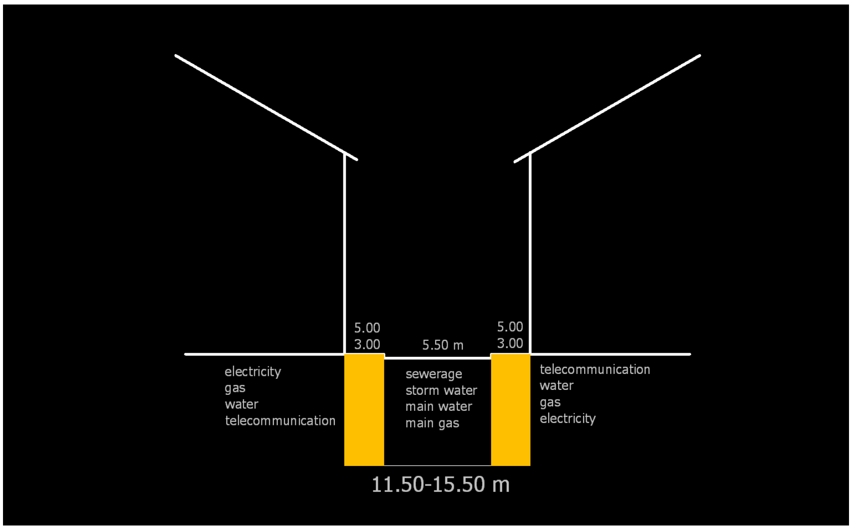


Group III



Group IV

Figure 2.4 Groups of roadways categorized by TS1097

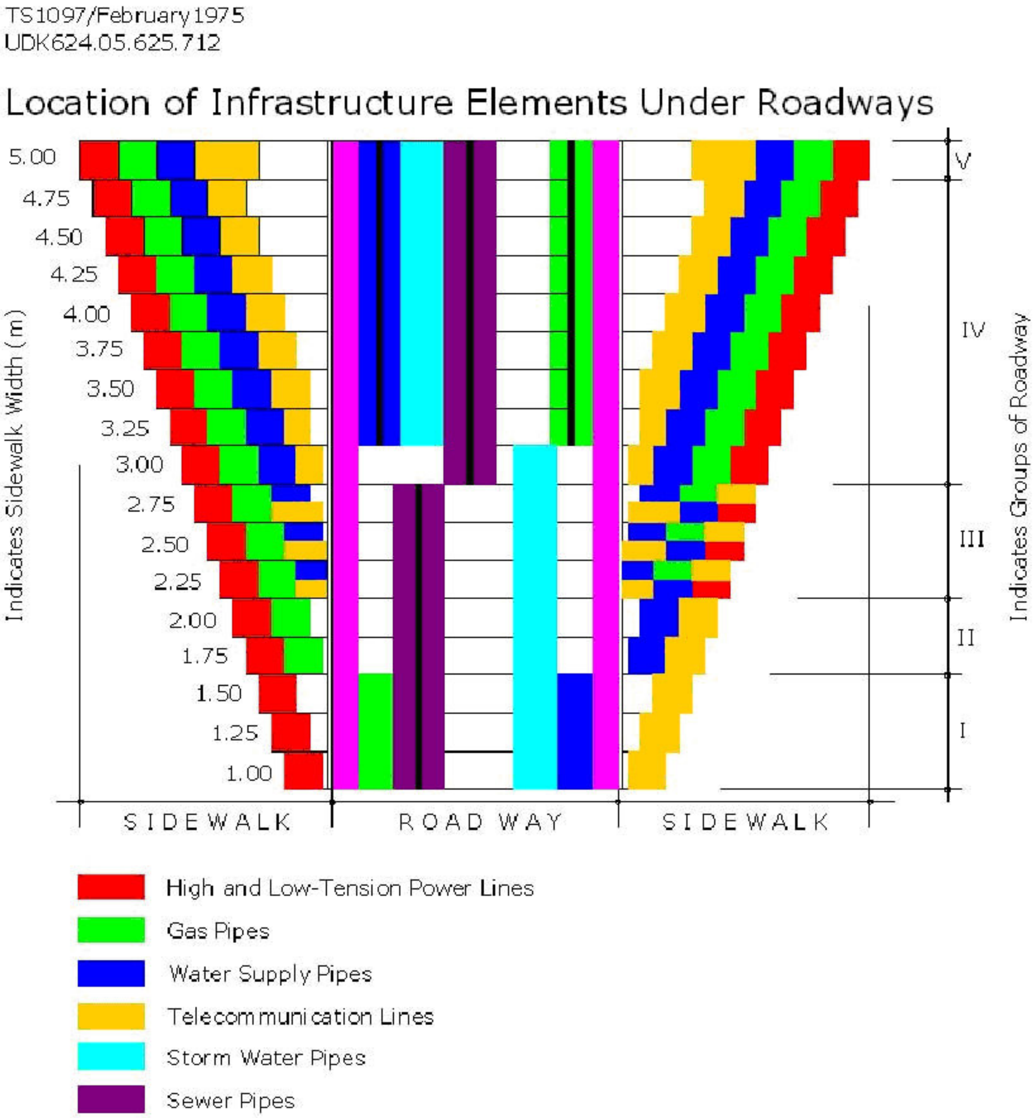


Figure 2.5. Location of Infrastructure Elements Under Roadways (TS1097 1975)

In general all infrastructure elements tend to locate under the sidewalks except for storm water and storm water. If sidewalk width is minimum 10.00 m, sewerage pipes can be located under the sidewalks.

2.3. Design Standards and Principles of Sewage Disposal System

In a sanitary sewer system there are seven components, house connection, lateral sewers, sub-mains, trunks, main collectors, treatment plants and discharge point. The system starts with house connections and ends up with collectors and treatment plant. (See Figure 2.6)

2.3.1. General Location

The system can be even gravity-flow or pumped system. Preferred system is always gravity-flow because it does not require energy (for pumping) and its maintenance cost is less. However, main collectors should be located on the appropriate slopefor gravity flow and if this slope can not be obtained, the system has to be a pumped one.

Main collectors do not have any user connections. After this stage, settlement's trunks are connected to the main collectors and user connections are started to be added to the system.

The number of sub-mains and lateral sewers is determined according to the cross section of the street. The main is installed at one side up to 30 m of cross section; if the street section is 30 m or more the mains are installed at both sides. Mains are laid under the pavements when they are under both sides of the street. Sanitary sewers are always installed under the other infrastructure systems. Vertically, the distance between the base of the potable water main and the upper level of the sewage main should be min. 30 cm; horizontally the difference should be min. 3.00 m.

Sub-mains and lateral sewers are the connection pipes between trunks and house connections. In attached housing area the mains are installed around the building blocks and each house's sewage is connected to the main. If the area is sloped and the buildings are in detached location, mains are installed at the lower parts of the buildings with one side. If there is a mass housing area and there isn't a sub-main around the dwellings, the sewage of the dwellings should be collected inside of the building block

(TS1097 1975).

There are different factors that effect sewer system and its selection.

- The most important one is topography, because sewer systems are gravity-flow system and they require adequate slope. These slopes are defined according to the type of sewer pipes in Iller bank's regulations for sanitary sewer projects as in the table.

Table 2.2. Slope Rate of Sewerage System Elements (Iller Bank Regulations, p.17)

Type of sewer	Diameter mm	Min slope	Normal	Max.slope
House connections	150	%1	%6	%14
Lateral sewers	200-300	%0.3	%6	%14
Sub-mains	350-600	%0.2	%4	%6
Trunks	650-1000	%0.1	%2	-
Main collector	1000-2000	%0.03	%1.3	-

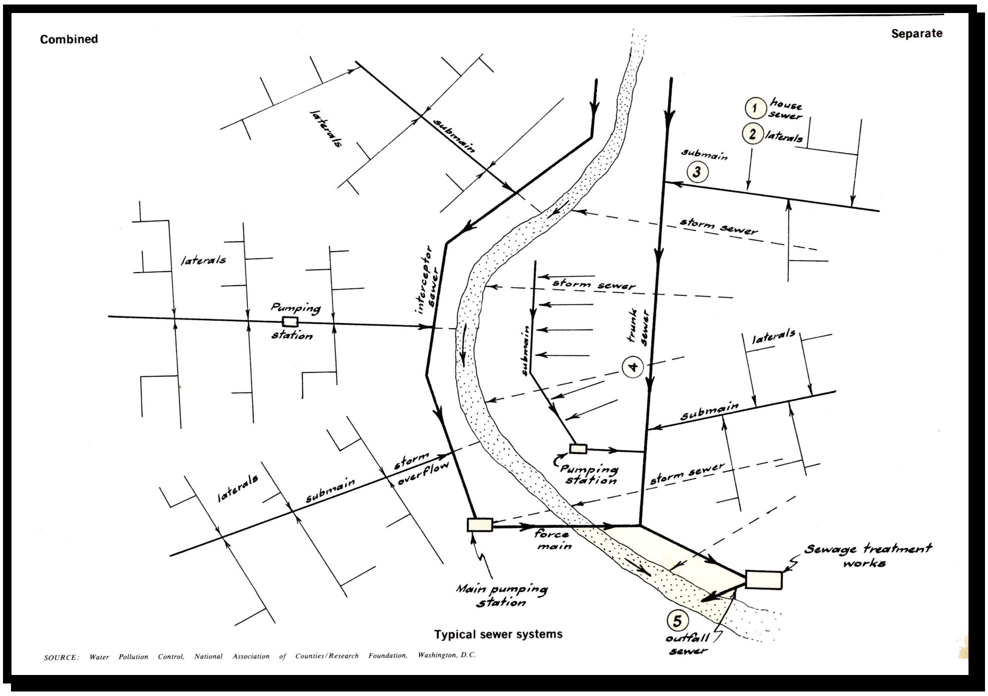


Figure 2.6 Typical Sewer Systems
(Source: Mc Cluskey 1969, p.297)

- Density and type of land use. This factor determines the diameter of the pipes and location.

- Other factors are situation of the buildings in the settlements (detached or attached housing, underground usages…) situations of the street and their coverage materials, existing situation of the water supply network, discharge points of the system and its features.

2.3.2. Type of Sewer System

There are two type of sewer system. One of them is combined and the other one is separated sewer system. Factors that are noticed by the comparison of them are:

- Separated system is more expensive as first investment cost because separated system needs two different pipelines.

- In the settlements near a river or a sea separated system is cheaper because storm water is discharged directly to the river or the sea by the shortest way.

- If the treatment plant is far away from the settlement, separated system is cheaper because storm drainage system requires large diameter pipe and as the system is separated, sewage is carried to the treatment plant with small diameter pipes while storm drainage is discharge to the receiver without treatment.

- Combined system has many transportation and management problems after construction, because storm water is also treated with sewage which is not necessary and, therefore, higher capacity treatment plants are needed.

- During hot climates storm water does not exist in combined system so that the flow of the sewage would be very little for the system. The particles in the wastewater would accumulate on pipe's base and they are decomposed by the effect of the climate which gives harm to the pipe and the environment.

2.3.3. Velocity and Flow Calculation

In sewage flow calculation, potable water calculations are taken into consideration. Additionally, potable water is supposed to be added to the system in 12 hours so and the system is calculated with this formula:

$Q= q * N /42300$	Q=Flow of sewage	N=Population
	q=Daily water consumption	1/2day=43200 sec

Sewer pipes require a max fullness ratio. This ratio in lateral sewers, sub-mains and in trunks is %60, in main collector it is %70. Fullness ratio is needed to obtain the gravity-flow and to provide the necessary gas emission in the pipe (Iller bank Regulations 1998).

For the prevention of corrosion and cracking of pipes there should be a max velocity of the sewage. The slope that forms this velocity is called the max gradient. This velocity in separated system is 2.5 m/sec, in combined system it is 4.0 m/sec. To provide the necessary slope on flat areas the depth of the sewer pipeline increases. As the system reaches to a depth of 7.00 m wastewater pumps are used to take the system up. Otherwise, excavation cost increase and the system will not be economic (Urban Design Standards Manual 1998).

2.3.4. Manhole Location

The maintenance of sewers is provided by manholes. Sewage network in the beginning manhole and its depth must be 1.80 m including the pipes diameter. After the placement of beginning manhole in each 50-60 m other manholes are placed with a depth of 1.90 m (at the beginning of the streets and at every street junction.) For the provision of the necessary gravity-flow depth of the manhole can be 6.00 - 7.00 m. If the slope of the street is more than the max gradient, the system is installed with the max. value of the slope according to the standards and at the necessary points drop type manholes are located. Dropping is provided by 90 angled pipes. The depth of the manhole shouldn't be more than 2.00 m in exceptional situations it can be max 4.00 m. As mentioned above in every 50-60 m of sewerage main, there should be a manhole located on the pipe. The reasons for constructing a manhole are: The maintenance of pipes can be provided, gas emission in the pipes can go out, and if the topography is not appropriate the necessary cleanings and pipe droppings can be obtained. In the region where the slope is smaller than the necessary value for a gravity-flow sanitary sewer system, the speed of sewage in the pipes will be at its min. value and in certain parts there will be accumulations of sewage particles. These accumulations have to be cleaned by pressurized water, so that, cleaning manholes are placed on these kind of region (Urban Design Standards Manual 1998).

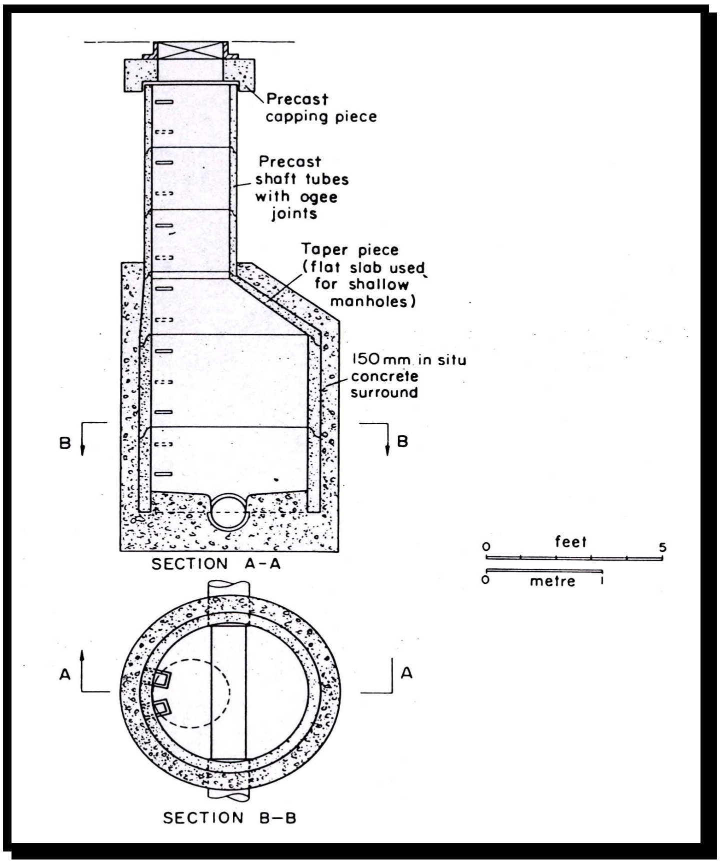


Figure 2.7. Precast-Concrete Manhole
(Source: White 1987, p.70)

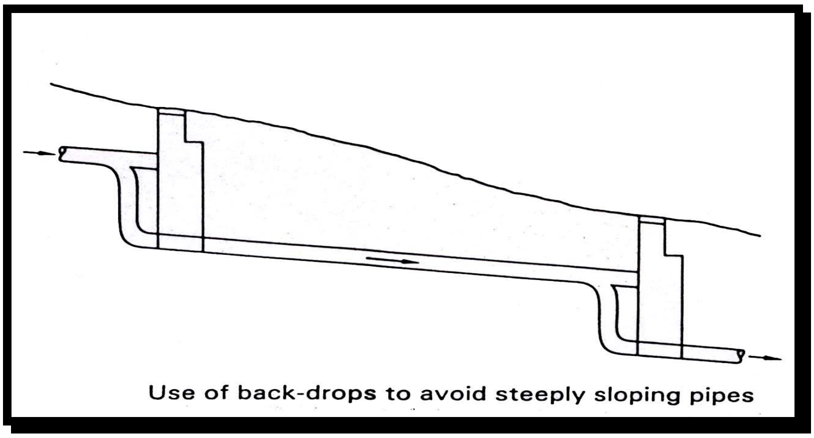


Figure 2.8. Cross-Section of Drop-manhole
(Source: White 1987, p.72)

Basically, collected sewages should be treated before being discharge to lakes, seas, streams or land. There are 5 basic disposal and discharge systems:

- Stream discharge
- Lake discharge
- Sea discharge
- Submarine outfalls
- Land disposal

2.4. Design Standards and Principles of Water Supply System

2.4.1. General

The primary purpose is to provide the community with an adequate supply of safe, potable water for drinking, cooking, personal hygiene and sanitary purposes. Water System mains are also designed to provide adequate flows for domestic and commercial uses and for fire protection, to protect the quality of the public water supply, and to maintain the integrity and reliability of the distribution system. Water mains shall be located on the North and East sides of streets and provide minimum 3.00 m horizontal separation from sanitary sewer. Fire hydrants will be located 0.90 m minimum from back of curb or 3.00 m minimum from edge of pavement if no curb is present (Lincoln Municipal Code 2003).

2.4.2. Main Size

The minimum main size is 15 cm diameter for residential areas, 20 cm diameter mains for commercial areas and 30 cm diameter for industrial areas should be required unless it can be demonstrated that a smaller main will provide the proposed and future development with adequate pressure and fire-flow. Large industrial or commercial developments may require larger mains to assure adequate pressure and fire-flow. The velocity in the main under non-fire flow conditions shall not exceed 1.50 m per second (Lincoln Municipal Code 2003).

2.4.3. Location

Water mains located in public or private residential streets should be placed outside of the roadway and 1.00 m from the back of curb. They are generally to be located on the north or east side of the streets except in areas with curvilinear street alignments where this orientation may be varied to avoid conflicts between the sanitary sewers and water mains (Lincoln Municipal Code 2003).

2.4.4. Horizontal Alignment

Water mains serving residential areas are to be constructed parallel to the centerline of the streets. On curvilinear alignments curves are to by accomplish by deflecting the pipe at its joints so long as the maximum permitted joint deflections are not exceeded. Where the curve radius requires pipe joint deflections greater than the amounts shown, bends must be used to negotiate the curved alignment. Bends should be chosen so that the main alignment is smooth and symmetrical (Lincoln Municipal Code 2003).

2.4.5. Vertical Alignment

The normal depth of cover for water mains is 1.50 m measured from the top of the curb, or finish grade, to the top of the pipe. The pipe should be designed and laid to line and grade and the grade should generally follow the finish grades of the street. The depth may be varied from 1.35 to 1.95 m where necessary to follow the street grades. Vertical pipe joint deflections necessary to maintain the required cover shall be made at convenient locations. Deflections greater than those permitted at pipe joints shall be accomplished using appropriate fittings (Lincoln Municipal Code 2003).

2.4.6. Thrust Restraint

Thrust blocks shall be placed at all main terminations, bends, tees, plugs, and other fittings where reaction blocking is necessary to resist movement and joint separation. Fire hydrants shall be installed with anchoring fittings. In situations where the water service can only be interrupted for limited periods, restrained joints shall be provided in addition to the thrust blocks to bear the loads until the concrete in the thrust blocks has gained sufficient strength to resist load application (Urban Design Standards Manual 2001).

2.4.7. Fire Hydrants

The following considerations govern the placement of fire hydrants:

- The entire area of the development must have adequate fire protection.

- In residential areas, fire hydrants shall be placed at intervals of 125 m measured along the centerline of the streets.

- In commercial or industrial areas, along arterial streets or in other high-risk areas. Fire Department may require additional hydrants be installed to provide adequate fire protection.

- Cul-de-sacs longer than 45 m but less than 120 m from the curb line of the intersected street to the end of the right-of-way in the cul-de- sac should have at least two fire hydrants, one at the intersecting street and one at the end of the water main in the cul-de-sac. A cul-de-sac less than 45 m long needs only a fire hydrant at the end of the main.

- Fire hydrants are generally to be located about 1.65 m behind the back of curb.

- Where there is an option in location, the fire hydrant should be located where on-street parking.

Fire hydrants in private systems should only be used where there is no alternate location on a public main (The City of Lincoln, the Department of Public Works and Utilities)

2.4.8. Valves

Valves should be spaced in feeder mains such that each feeder loop can be isolated. Distribution main valves should be spaced so that adequate shutdown capability is provided without placing large numbers of customers out of service. On 15 cm diameter mains, valves should generally be placed no more than 182.9 m) apart. Gate valves are used in mains smaller than 30 cm in diameter. Butterfly valves are used in 30 cm diameter and larger mains. Valves should be located opposite street right-of-way lines or opposite abutting lot lines for ease in location (Urban Design Standards Manual 2001).

2.4.9. Parallel Sewer and Water Mains

Water mains shall be separated by at least 3.48 m horizontally from any existing or proposed parallel sanitary sewer. If extremely unusual conditions do not permit that horizontal separation, the water main may be laid closer to the sanitary sewer provided it is laid in a separate trench and the elevation of the bottom of the water main is at least 45.7 cm above the top of the sanitary sewer (Lincoln Municipal Code 2003).

2.4.10. Sanitary Sewer Crossings

Water mains shall be laid at such an elevation that the bottom of the water main is at least 45.7 cm above the top of the sanitary sewer pipe. In those instances where the bottom of the water main is less than 45.7 cm, above the top of the sanitary sewer or the sanitary sewer is located (The City of Lincoln, the Department of Public Works and Utilities)

2.5. Design Standards and Principles of Storm Drainage System

The primary purpose is the removal of storm-water runoff to prevent flooding. Flooding results in high material damage, washing away streets, sidewalks, undermining building footings and threatening water supplies by infiltration and contamination. The flow concentration collectors are ditches and pipes. Design criteria and requirements for two levels are outlined below.

2.5.1. Minimum Level:

"It is basically a system of deep and shallow ditches. Interior streets contain primary drainage interceptors: shallow ditches. Perimeter streets contain primary drainage interceptors as above and the flow concentration collectors: shallow and deep ditches (earth formed or lined), culverts" (Caminos et.al 1978, p.134).

2.5.2. Standard Level:

"It is basically a system of gutters and underground pipes. Interior streets contain primary drainage interceptors: curb-gutter. Perimeter streets contain primary drainage interceptors as above and the flow concentration collectors: underground pipes, manholes, street inlets.

Storm Drainage Capacity Design (Q) = c i a

Q = runoff area to be drained (m^3 / second)

c = coefficient of runoff

i = average rainfall intensity per hectare

a = area to be drained" (Caminos et.al 1978, p.134).

The rainwater down pipes from the roof of any building must be connected into the drainage system in a similar manner. By the careful planning of inverts it may be possible to contain both the underground surface water and foul drains into one trench with a consequent considerable saving in the cost of excavation and backfilling and ground reinstatement. This system necessitates manholes large enough to contain two 10 cm or 15 cm pipes; the soil or foul drain must always be a sealed system to prevent overflow into the surface water drain, which may be an open channel. *"The use of soak ways to take all or some of the surface water runoff from an estate may only be considered if the ground is suitable for its dispersal. Soak ways may be constructed in two forms- filled and unfilled- but it is recommended that filled forms are only used for the drainage of very small surface areas in soils of high permeability as they are likely to become chocked; their effectiveness will, in time, reduced. In certain parts of the country, and particularly in old inner city areas, it is pointless and unnecessary to provide separate systems between the building periphery drains and the sewer outfall as the authority sewer will inevitably be "combined". In this case the two drains foul and surface water can be joined together at some convenient manhole and to prevent foul sewer gasses venting via untrapped rain or surface water outlets an interceptor must be provided."* (Payne 1982, p.36).

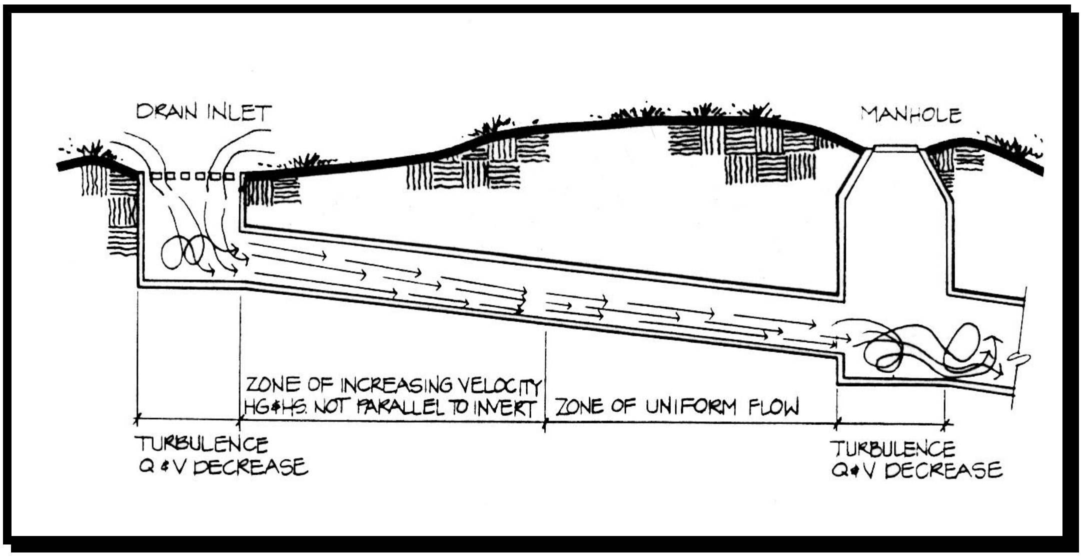


Figure 2.9. Land Section for Storm Drainage
(Source: Harris 1988, p.42)

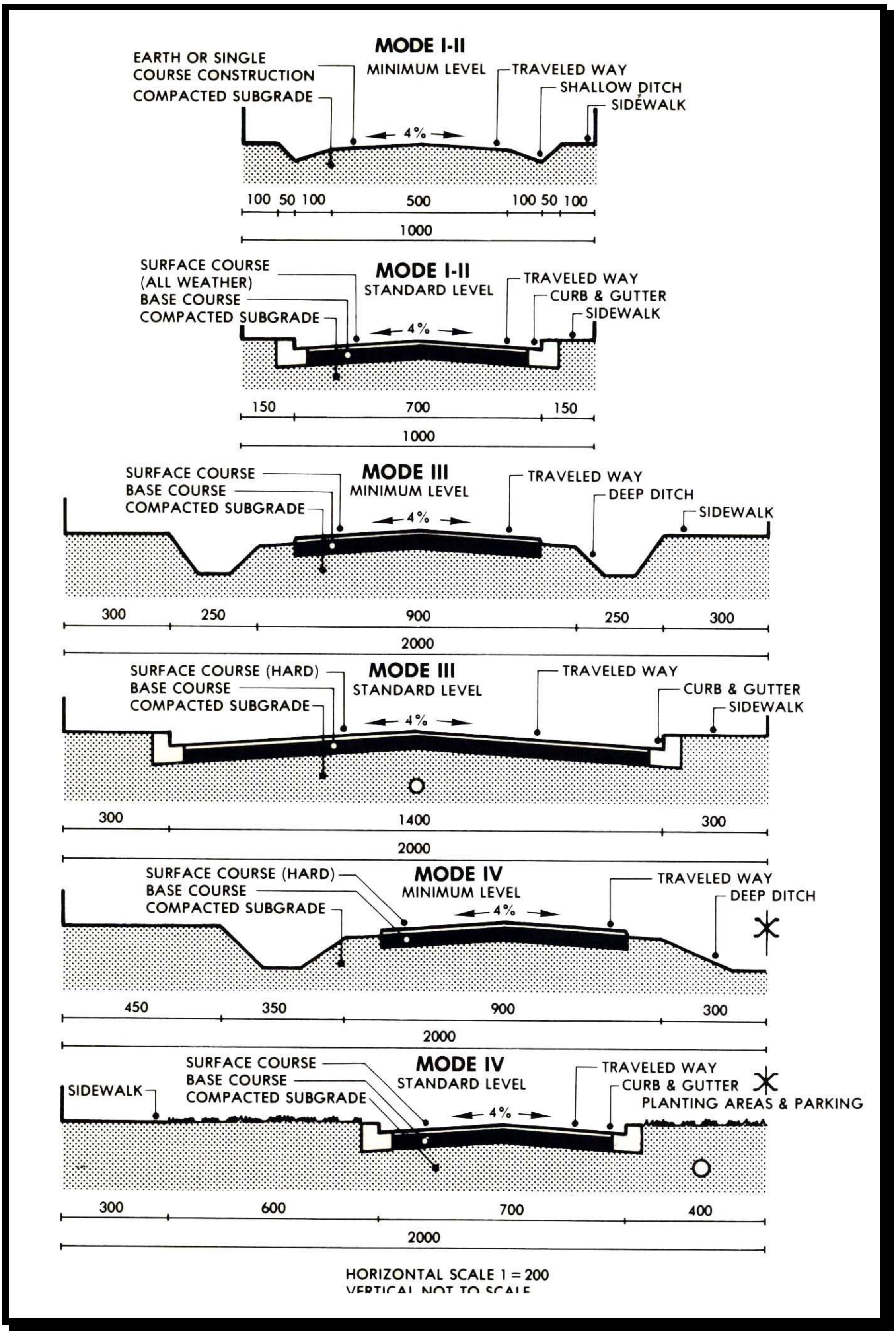


Figure 2.10 Type of Drainage in Road Cross Section
(Source: Caminos 1978, p.136)

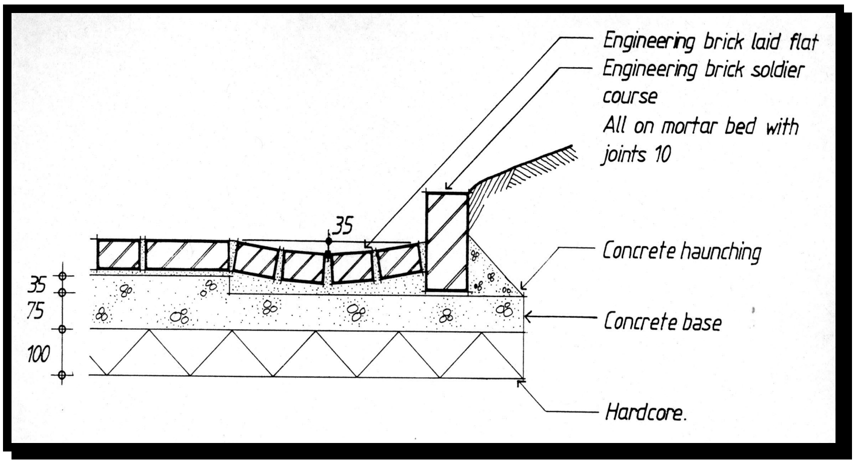


Figure 2.11. Section of Brick Drainage Channel
(Source: Littlewood 1993, p.184)

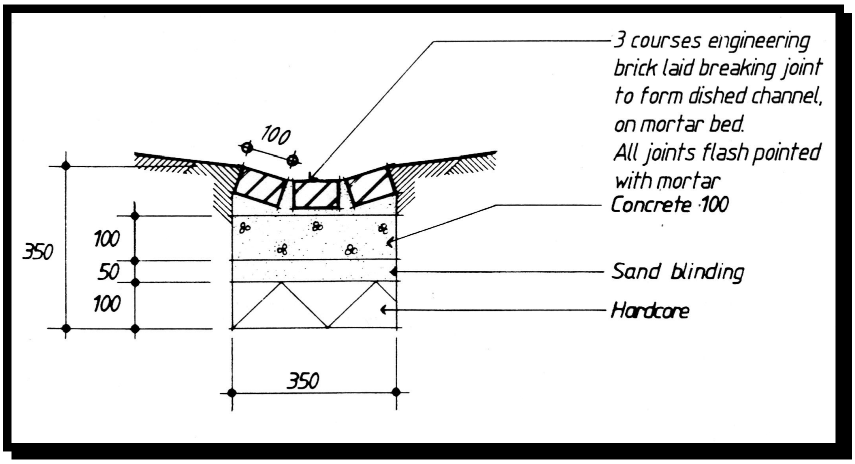


Figure 2.12 Section of Brick Drainage Channel
(Source: Littlewood 1993, p.183)

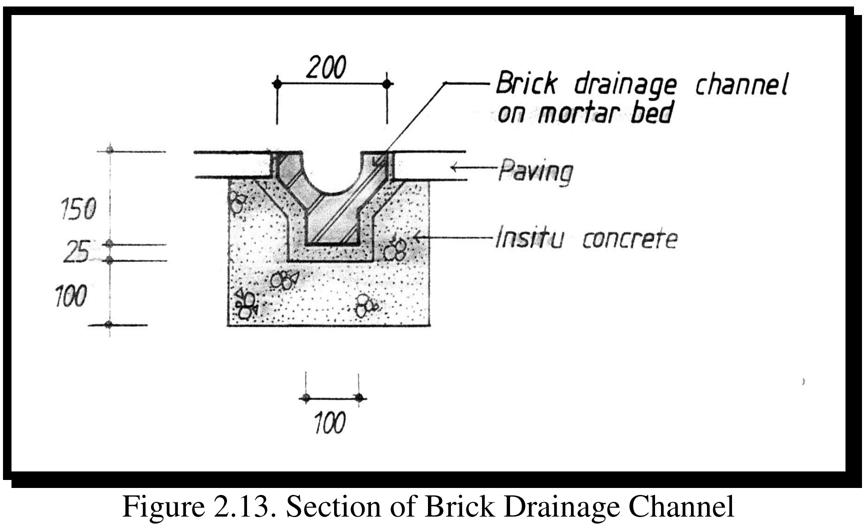


Figure 2.13. Section of Brick Drainage Channel
(Source: Littlewood 1993, p.183)

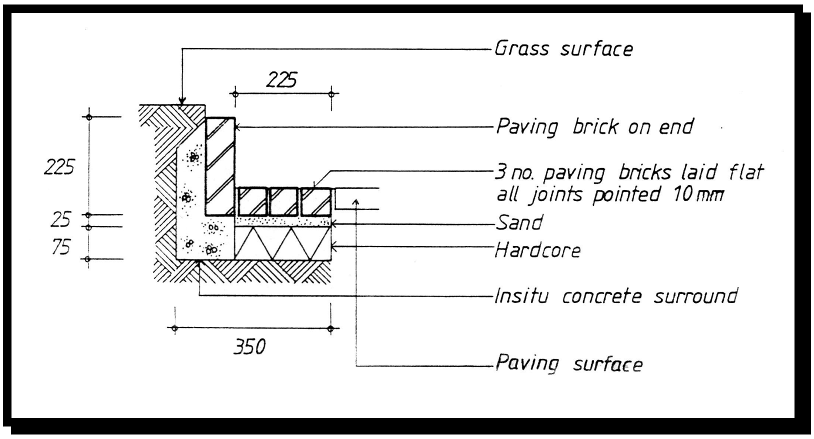


Figure 2.14 Section of Brick Drainage Channel
(Source: Littlewood 1993, p.184)

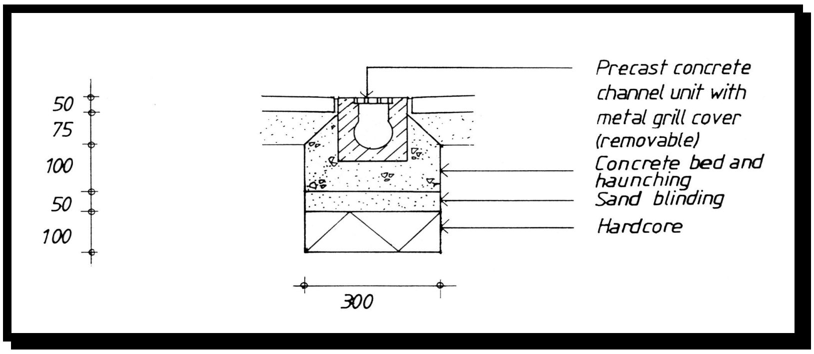


Figure 2.15 Section of Metal Drainage Channel
(Source: Littlewood 1993, p.194)

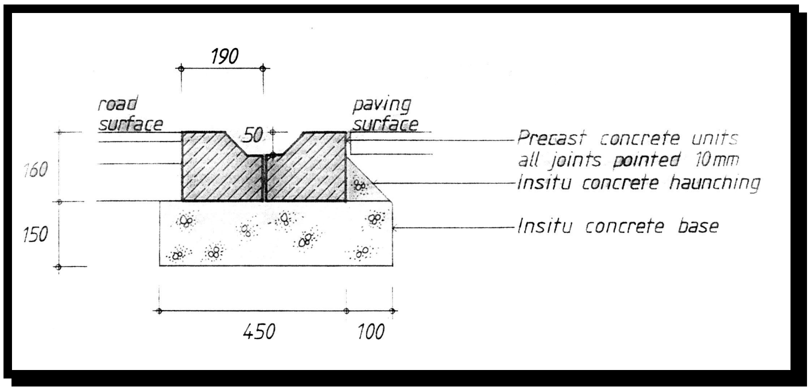


Figure 2.16 Section of precast Concrete Drainage Channel
(Source: Littlewood 1993, p.185)

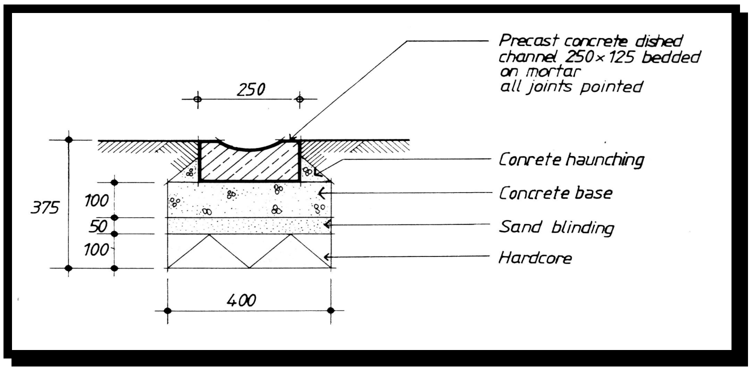


Figure 2.17. Section of Precast Concrete Drainage Channel
(Littlewood 1993, p.185)

2.6. Design Standards and Principles of Aboveground Lighting System

The purpose of site lighting is basically twofold: (1) illuminate and (2) to provide security. Lighting should be provided in areas that receive heavy pedestrian or vehicular use and in areas that are dangerous if unlit, such as stairs and ramps, intersections or abrupt changes in grade. Likewise, areas that have high crime rates should be well lit in order that people traveling at night may feel personally secure from attack. The phrase “well lit “has a wider meaning than simply higher light levels. Unless light is placed where it is really the most useful, the expense of increasing foot-candle levels is wasted. An area may need only the addition of a few more lights to correct its problems, not an increase in light levels from fixtures that are too few, or poorly located (Robinette 1985).

When considering the installation or renovation of lighting systems, the designer should be aware of the following considerations:

- Overhead lamps have the advantage over low lever fixtures of providing better economy and more even light distribution. Fixtures should be placed so that light patterns overlap at a height of 2.10 cm, which is sufficiently high to vertically illuminate a person’s body. This is particularly important consideration now that lighting fixture manufacturers are designing luminaries with highly controlled light patterns.

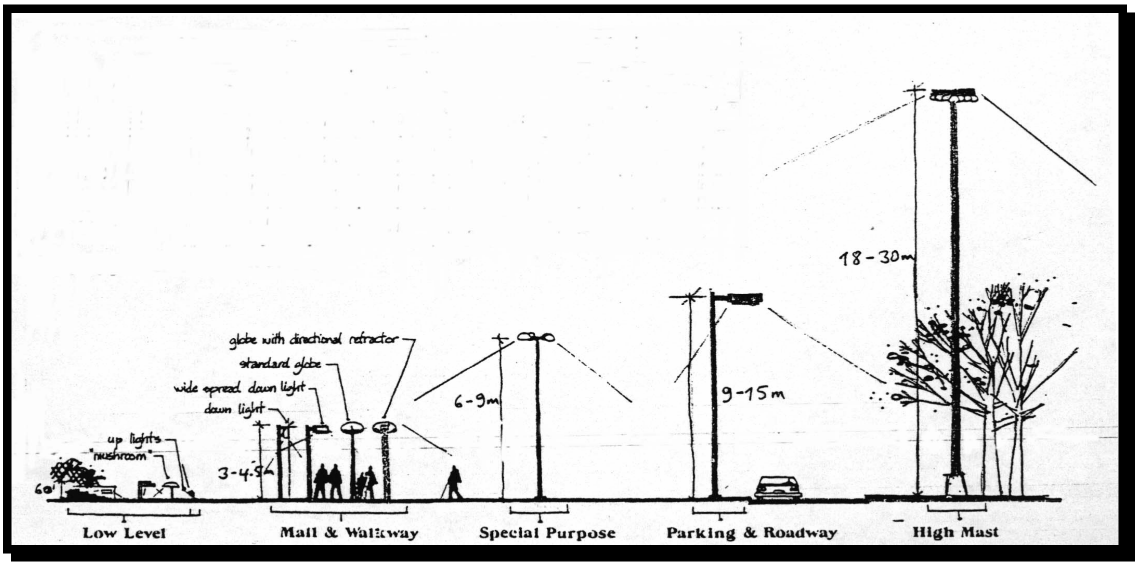


Figure 2.18 Type of lighting
(Source: Robinette 1985, p.84)

- At hazardous locations such as changes of grate, lower lever supplemental lighting or additional overhead unit should be used.

- Where low lever lighting is used fixtures should be placed in such a way that they do not produce glare. Most eye levels occur between 110 cm (for wheelchair users) and 1.80 for standing adults.

- Posts and standards along thoroughfares should be placed so that they do not present hazard to pedestrians or vehicles.

- A minor consideration is the use of shatterproof coverings on low-level lighting where there is the change of breakage from vandalism or mishaps from people playing Frisbee, football, etc. The absence of any resulting broken material will reduce otherwise potential hazards.

- When walkway lighting provided primarily by low fixtures, there should be sufficient peripheral lighting to illuminate the immediate surroundings. Peripheral lighting provides for a better feeling of security for an individual since he can see into his surroundings to determine whether or not passage through an area is safe. Such lighting should be approached from one of two ways:

a: By lighting the area so that an object or person may be seen directly.

b: By lighting the area to place an object or person in silhouette (Robinette, 1985).

When deciding horizontal length between lighting fixtures and providing efficient usage, "Cut off Terminology", "Types of Distribution", Transverse Road Line, Longitudinal Road Line are important terminology. Types of Distribution (short, medium and long) determine the distance between lighting fixtures. Mounting height should be multiplied 3.75, 6.0, and 8.0 for short, medium and long types of distribution respectively. Additionally, cut-off terminology determines the lighting distribution on the transverse road line (Robinette 1985).

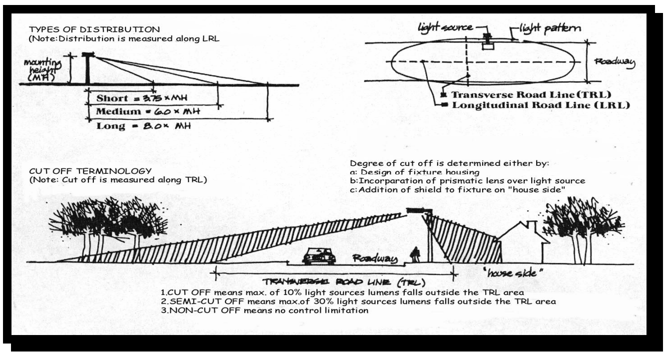


Figure 2.19. Types of Distribution
(Source: Robinette 1985, p.84)

CHAPTER 3

ALTERNATIVE SOLUTIONS FOR REDUCING INFRASTRUCTURE INVESTMENT COST

For reducing public investment cost of infrastructure, reducing total amount of road length and searching for alternative location for service utilities within the urban settlement seems to be possible solution. Because, linear infrastructure generally installed under the road surface along with the longitudinal road line. Shorten the road length can only be possible developing alternative development pattern such as; "Hexagonal development pattern" or "Compact Urban Form". Using different building types and number of storey decisions that has been described by Turkish "*model building by-law*", created various residential development patterns with different density decisions compared and analyzed with respect to cost of infrastructure.

3.1. Searching for Alternative Location for Utilities

Whatever building type would be on building block either with subdivision or cluster system has to be surrounded by roadways or pedestrian ways. Additionally, required urban technical infrastructure elements such as; water supply, sewer system, electricity, telecommunication and gas...etc has to be located under these roadways. As a whole, the way these building blocks getting together basically constitute 2D structure of urban development.

Main determinants of 2D urban macroform are;

- Location standards and requirements of urban land use types,
- Relationship between urban land use types and space requirements of them,
- Structure of the circulation scheme.

However, various density decisions for the whole settlement determine the size of the city. That is 3D determinants of the settlement are;

- type of construction (detached, semi-detached, terraced, block...)
- number of storey.

So far, traditional planning practice has required space for urban technical infrastructure under urban traffic routes. It means that infrastructure construction cost is directly related with total roadway length, coverage area and size of the settlement. However, it can be reduced by alternative size and location of them within urban settlement.

In order to achieve this goal, at first place, average building block length defined for each building type that varied detached to apartment block. Then, calculated space for infrastructure elements in the centerline of the building block shapes the proposed building block and using all proposed and existing building blocks 2800 dwelling units of neighborhood formed. Later, comparative statistical analysis for total area, total perimeter, total road length and total road coverage area of each building type were performed.

Alternative solution for location of infrastructure elements is under the centerline of the building block. In general, all infrastructure elements tend to locate under the sidewalks except for storm water and sewer system. If sidewalk width is minimum 10.00 m, sewerage pipes can be located under the sidewalks. But for reducing urban technical infrastructure investment cost, alternative location for certain types of infrastructure elements should be considered for future urban development patterns. For this purpose, alternative building block can be designed that take account of public space (5.75 m in width) in the centerline of the building block. Except for main water and gas pipelines, all infrastructure elements would be taken a place backyard of the each parcel. See Figure 3.1

In width;

Electricity	0.80 m
Telecommunication	0.85 m
Lateral Water Supply	0.70 m
Lateral Gas pipe	0.70 m
Sewerage	1.50 m
Storm Water	1.20 m
	5.75 m

total space requirement can be reserved for public usage. If storm water and electricity locate under roadways and sidewalks total space requirement would be reduced to 3.75 m in width.

Compared to proposed 8 storey terraced building block, traditional rectangular building block dimension is increased 73m X 54m to 73m X 59.75 m. Although this figures represents 10.6%, 4.5% and 3.5% increase in terms of building block's coverage area and perimeter and total road length respectively, larger area examined for neighborhood that consists of 2800 dwelling unit has %13.4 decrease of total infrastructure length. (See Figure 3.2, 3.3) With this alternative, in terms of providing infrastructure elements, residential neighborhood unit of 2800 dwellings assumed as a single development district that provide its services within its structure and then connect the main collectors of cities.

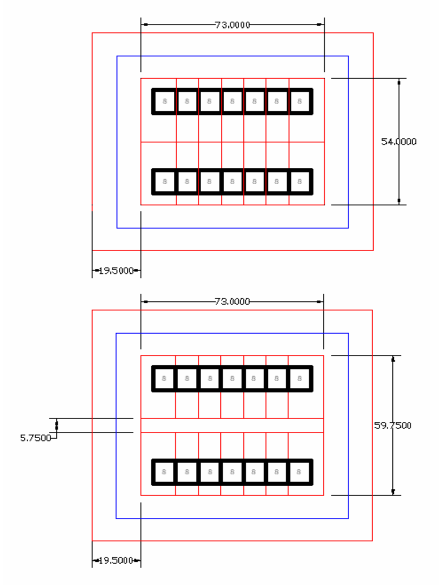


Figure 3.1 Proposed Building Block for 8 Storey Terraced Housing

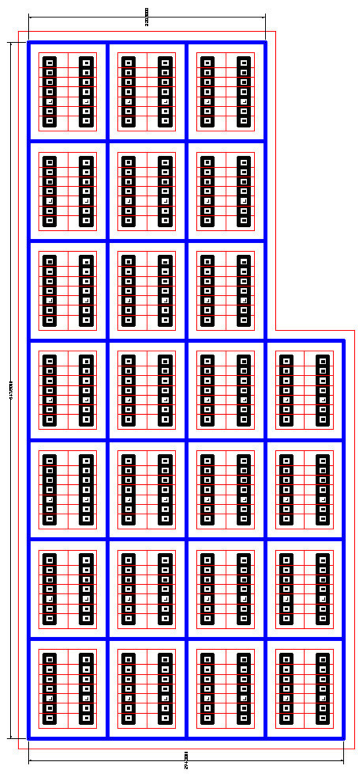


Figure 3.2 Terraced 8 Storey Housing Neighborhood for 2800 units

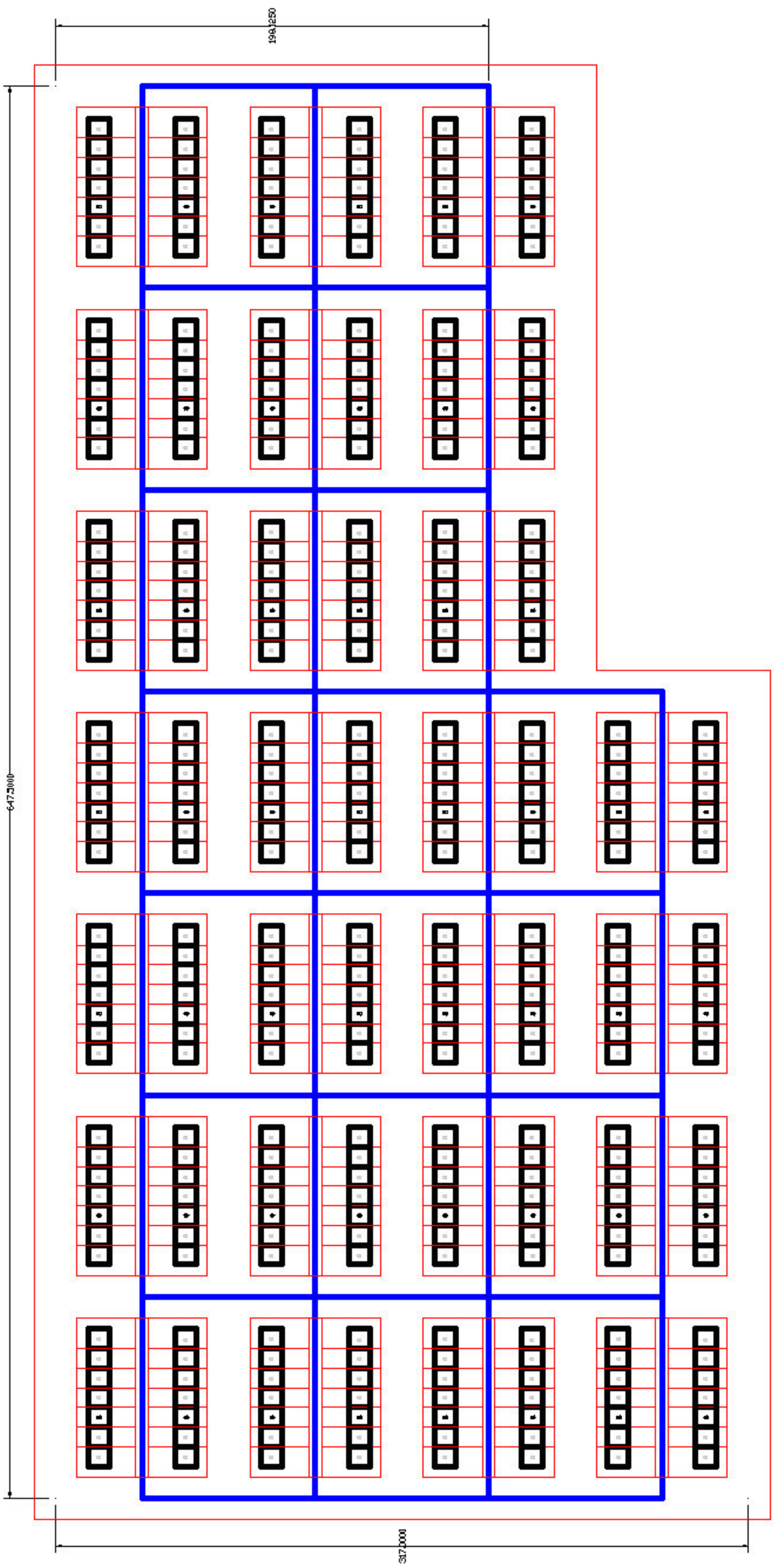


Figure 3.3 Proposed Terraced 8 Storey Housing Neighborhood for 2800 units

At this point it can be stated that total road length increase average 4.9% but Infrastructure length decrease 13.4%.

Table 3.1. Single Construction Area Comparison Table for Proposed Type Construction

	DETACHED (dublex or triplex)							DETACHED						Incr.Rate Based to detached	SEMI-DETACHED						Incr.Rate Based to detached	TERRACED						Incr.Rate Based to detached	APARTMENT BLOCK						Incr.Rate Based to detached		
2 Storey	Length (m)	72,00						72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
	72,00	Number of Units	12,00						24,00					2,000		32,00					1,333		44,00					1,833		40,00					1,667	Number of Units	
		12,00	Area (m2)	2808,00						2808,00				0			2808,00				0			2808,00				0			2808,00				0	Area (m2)	
			2808,00	Perimeter (m)	222,00						222,00			0				222,00			0				222,00			0				222,00			0	Perimeter (m)	
				222,00	TRL (m)	250,00						250,00		0					250,00		0					250,00		0					250,00		0	TRL (m)	
					250,00	TRCA (m2)	1750,00						1750,00	0						1750,00	0						1750,00	0						1750,00	0	TRCA (m2)	
						1750,00																															
Proposed 2 Storey	Length (m)	72,00						72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
	72,00	Number of Units	12						24,00					2,000		32,00					1,333		44,00					1,833		40,00					1,667	Number of Units	
		12,00	Area (m2)	3222						3222,00				0			3222,00				0			3222,00				0			3222,00				0	Area (m2)	
			3222,00	Perimeter (m)	233,5						233,50			0				233,50			0				233,50			0				233,50			0	Perimeter (m)	
				233,50	TRL (m)	261,5						261,50		0					261,50		0					261,50		0					261,50		0	TRL (m)	
					261,50	TRCA (m2)	1830,5						1830,50	0						1830,50	0						1830,50	0						1830,50	0	TRCA (m2)	
						1830,50																															
Increase rate	0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046			
3 Storey	Length (m)	72,00						72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
	72,00	Number of Units	12,00						36,00					3,000		48,00					1,333		66,00					1,833		60,00					1,667	Number of Units	
		12,00	Area (m2)	2808,00						2808,00				0			2808,00				0			2808,00				0			2808,00				0	Area (m2)	
			2808,00	Perimeter (m)	222,00						222,00			0				222,00			0				222,00			0				222,00			0	Perimeter (m)	
				222,00	TRL (m)	250,00						250,00		0					250,00		0					250,00		0					250,00		0	TRL (m)	
					250,00	TRCA (m2)	1750,00						1750,00	0						1750,00	0						1750,00	0						1750,00	0	TRCA (m2)	
						1750,00															0																
Proposed 3 Storey	Length (m)	72,00						72,00						0	72,00							72,00						0	72,00						0	Length (m)	
	72,00	Number of Units	12,00						36,00					3,000		48,00					1,333		66,00					1,833		60,00					1,667	Number of Units	
		12,00	Area (m2)	3222,00						3222,00				0			3222,00				0			3222,00				0			3222,00				0	Area (m2)	
			3222,00	Perimeter (m)	233,50						233,50			0				233,50			0				233,50			0				233,50			0	Perimeter (m)	
				233,50	TRL (m)	261,50						261,50		0					261,50		0					261,50		0					261,50		0	TRL (m)	
					261,50	TRCA (m2)	1830,50						1830,50	0						1830,50	0						1830,50	0						1830,50	0	TRCA (m2)	
						1830,50																															
Increase rate	0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046		0,000	0,000	1,147	1,052	1,046	1,046			
4 Storey	Length (m)							72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
		Number of Units							48,00					0		64,00					1,333		88,00					1,833		80,00					1,667	Number of Units	
			Area (m2)							3024,00				0			3024,00				0			3024,00				0			3024,00				0	Area (m2)	
				Perimeter (m)							228,00			0				228,00			0				228,00			0				228,00			0	Perimeter (m)	
					TRL (m)							266,00		0					266,00		0					266,00		0					266,00		0	TRL (m)	
						TRCA (m2)							2527,00	0						2527,00	0						2527,00	0						2527,00	0	TRCA (m2)	
Proposed 4 Storey	Length (m)							72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
		Number of Units							48,00					0		64,00					1,333		88,00					1,833		80,00					1,667	Number of Units	
			Area (m2)							3438,00				0			3438,00				0			3438,00				0			3438,00				0	Area (m2)	
				Perimeter (m)							239,50			0				239,50			0				239,50			0				239,50			0	Perimeter (m)	
					TRL (m)							277,50		0					277,50		0					277,50		0					277,50		0	TRL (m)	
						TRCA (m2)							2636,25	0						2636,25	0						2636,25	0						2636,25	0	TRCA (m2)	
Increase rate								0,000	0,000	1,137	1,050	1,043	1,043		0,000	0,000	1,137	1,050	1,043	1,043		0,000	0,000	1,137	1,050	1,043	1,043		0,000	0,000	1,137	1,050	1,043	1,043			
5 Storey	Length (m)							64,00						0	75,00						0	70,00						0	68,00						0	Length (m)	
		Number of Units							40,00					0		60,00					1,500		70,00					1,750		60,00					1,500	Number of Units	
			Area (m2)							2880,00				0			3375,00				0			3150,00				0			3060,00				0	Area (m2)	
				Perimeter (m)							218,00			0				240,00			0				230,00			0				226,00			0	Perimeter (m)	
					TRL (m)							266,00		0					288,00		0					278,00		0					274,00		0	TRL (m)	
						TRCA (m2)							3192,00	0						3456,00	0						3336,00	0						3288,00	0	TRCA (m2)	
Proposed 5 Storey	Length (m)							64,00						0	75,00						0	70,00						0	68,00						0	Length (m)	
		Number of Units							40,00					0		60,00					1,500		70,00					1,750		60,00					1,500	Number of Units	
			Area (m2)							3248,00				0			3806,25				0			3552,50				0			3451,00				0	Area (m2)	
				Perimeter (m)							229,50			0				251,50			0				241,50			0				237,50			0	Perimeter (m)	
					TRL (m)							277,50		0					299,50		0					289,50		0					285,50		0	TRL (m)	
						TRCA (m2)							3330,00	0						3594,00	0						3474,00	0						3426,00	0	TRCA (m2)	
Increase rate								0,000	0,000	1,128	1,053	1,043	1,043		0,000	0,000	1,128	1,048	1,040	1,040		0,000	0,000	1,128	1,050	1,041	1,041		0,000	0,000	1,128	1,051	1,042	1,042			
6 Storey	Length (m)							68,00						0	69,00						0	71,00						0	70,00						0	Length (m)	
		Number of Units							48,00					0		60,00					1,250		84,00					1,750		72,00					1,500	Number of Units	
			Area (m2)							3264,00				0			3312,00				0			3408,00				0			3360,00				0	Area (m2)	
				Perimeter (m)							232,00			0				234,00			0				238,00			0				236,00			0	Perimeter (m)	
					TRL (m)							290,00		0					292,00		0					296,00		0					294,00		0	TRL (m)	
						TRCA (m2)							4205,00	0						4234,00	0						4292,00	0						4263,00	0	TRCA (m2)	
Proposed 6 Storey	Length (m)							68,00						0	69,00						0	71,00						0	70,00						0	Length (m)	
		Number of Units							48,00					0		60,00					1,250		84,00					1,750		72,00					1,500	Number of Units	
			Area (m2)							3655,00				0			3708,75				0			3816,25				0			3762,50				0	Area (m2)	
				Perimeter (m)							243,50			0				245,50			0				249,50			0				247,50			0	Perimeter (m)	
					TRL (m)							301,50		0					303,50		0					307,50		0					305,50		0	TRL (m)	
						TRCA (m2)							4371,75	0						4400,75	0						4458,75	0						4429,75	0	TRCA (m2)	
Increase rate								0,000	0,000	1,120	1,050	1,040	1,040		0,000	0,000	1,120	1,049	1,039	1,039		0,000	0,000	1,120	1,048	1,039	1,039		0,000	0,000	1,120	1,049		1,039			
7 Storey	Length (m)							72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
		Number of Units							56,00					0		70,00					1,250		98,00					1,750		84,00					1,500	Number of Units	
			Area (m2)							3672,00				0			3672,00				0			3672,00				0			3672,00				0	Area (m2)	
				Perimeter (m)							246,00			0				246,00			0				246,00			0				246,00			0	Perimeter (m)	
					TRL (m)							314,00		0					314,00		0					314,00		0					314,00		0	TRL (m)	
						TRCA (m2)							5338,00	0						5338,00	0						5338,00	0						5338,00	0	TRCA (m2)	
Proposed 7 Storey	Length (m)							72,00						0	72,00						0	72,00						0	72,00						0	Length (m)	
		Number of Units							56,00					0		70,00					1,250		98,00					1,750		84,00					1,500	Number of Units	
			Area (m2)							4086,00				0			4086,00				0			4086,00				0			4086,00				0	Area (m2)	
				Perimeter (m)							257,50			0				257,50			0				257,50			0				257,50			0	Perimeter (m)	
					TRL (m)							325,50		0					325,50		0					325,50		0					325,50		0	TRL (m)	
						TRCA (m2)							5533,50	0						5533,50	0						5533,50	0						5533,50	0	TRCA (m2)	
Increase rate								0,000	0,000	1,113	1,047	1,037	1,037		0,000	0,000	1,113	1,047	1,037	1,037		0,000	0,000	1,113	1,047	1,037	1,037		0,000	0,000	1,113	1,047	1,037	1,037			
8 Storey	Length (m)							76,00						0	75,00						0	73,00						0	74,00						0	Length (m)	
		Number of Units							64,00					0		80,00					1,250		112,00					1,750		96,00					1,500	Number of Units	
			Area (m2)							4104,00				0			4050,00				0			3942,00				0			3996,00				0	Area (m2)	
				Perimeter (m)							260,00			0				258,00			0				254,00			0				256,00			0	Perimeter (m)	
					TRL (m)							338,00		0					336,00		0					332,00		0					334,00		0	TRL (m)	
						TRCA (m2)							6591,00	0						6552,00	0						6474,00	0						6513,00	0	TRCA (m2)	
Proposed 8 Storey	Length (m)							76,00						0	75,00						0	73,00						0	74,00						0	Length (m)	
		Number of Units							64,00					0		80,00					1,250		112,00					1,750		96,00					1,500	Number of Units	
			Area (m2)							4541,00				0			4481,00				0			4361,75				0			4421,50				0	Area (m2)	
				Perimeter (m)							271,50			0				259,50			0				265,50			0				267,50			0	Perimeter (m)	
					TRL (m)							349,50		0					347,50		0					343,50		0					345,50		0	TRL (m)	
						TRCA (m2)							6815,25	0						6776,25	0						6698,25	0						6737,25	0	TRCA (m2)	
Increase rate								0,000	0,000	1,106	1,044	1,034	1,034		0,000	0,000	1,106	1,006	1,034	1,034		0,000	0,000	1,106	1,045	1,035	1,035		0,000	0,000	1,106	1,045	1,034	1,034			

Table 3.2. Comparison between conventional rectangular building blocks and Proposed one for 2800 units

	DETACHED (dublex or triplex)						DETACHED					Decr.Rate Based to Detached	SEMI-DETACHED					Decr.Rate Based to Detached	TERRACED					Decr.Rate Based to Detached	APARTMENT BLOCK					Decr.Rate Based to Detached		average	max	min
2 Storey	Area (m2)	848148,00					424074,00					0,500	318136,00					0,750	231472,00					0,546	252770,00					0,596	Area (m2)	0,598	0,750	0,500
	848148,00	Perimeter (m)	3776,00					2750,00				0,728		2474,00				0,900		2158,00				0,785		2214,00				0,805	Perimeter (m)	0,804	0,900	0,728
		3776,00	TRL (m)	30824,00					15794,00			0,512			12012,00			0,761			8950,00			0,567			9720,00			0,615	TRL (m)	0,614	0,761	0,512
			30824,00	TRCA (m2)	202552,00					100933,00		0,498				75425,00		0,747				55097,00		0,546				60291,00		0,597	TRCA (m2)	0,597	0,747	0,498
				202552,00	Infrastructure Length (m)	30824,00					15794,00	0,512					12012,00	0,761					8950,00	0,567					9720,00	0,615	Infrastructure Length	0,614	0,761	0,512
					30824,00																													
Proposed 2 Storey	Area (m2)	954144,39					477083,25					0,500	357903,00					0,750	260406,00					0,546	286177,25					0,600	Area (m2)	0,599	0,750	0,500
	954144,39	Perimeter (m)	3971,50					2876,50				0,724		2566,00				0,892		2250,00				0,782		2304,50				0,801	Perimeter (m)	0,800	0,892	0,724
		3971,50	TRL (m)	32266,82					16530,00			0,512			12564,00			0,760			9364,00			0,566			10204,75			0,617	TRL (m)	0,614	0,760	0,512
			32266,82	TRCA (m2)	211967,49					105642,25		0,498				78967,00		0,747				57673,00		0,546				63360,00		0,600	TRCA (m2)	0,598	0,747	0,498
				211967,49	Infrastructure Length	30246,94					15020,00	0,497					10896,50	0,725					8125,75	0,541					9388,75	0,625	Infrastructure Length	0,597	0,725	0,497
					30246,94																													
Increase rate	1,125	1,052	1,047	1,046	0,981		1,125	1,046	1,047	1,047	0,951		1,125	1,037	1,046	1,047	0,907		1,125	1,043	1,046	1,047	0,908		1,132	1,041	1,050	1,051	0,966					
3 Storey	Area (m2)	848148,00					282900,00					0,334	212474,00					0,751	154606,00					0,547	168912,00					0,597	Area (m2)	0,557	0,751	0,334
	848148,00	Perimeter (m)	3776,00					2474,00				0,655		2000,00				0,808		1750,00				0,707		1743,00				0,161	Perimeter (m)	0,583	0,808	0,161
		3776,00	TRL (m)	30824,00					10856,00			0,352			8221,00			0,757			6130,00			0,565			6596,00			0,608	TRL (m)	0,570	0,757	0,352
			30824,00	TRCA (m2)	202552,00					67333,00		0,332				50547,00		0,751				36785,00		0,546				40071,50		0,595	TRCA (m2)	0,556	0,751	0,332
				202552,00	Infrastructure Length	30824,00					10856,00	0,352					8221,00	0,757					6130,00	0,565					6596,00	0,608	Infrastructure Length	0,570	0,757	0,352
					30824,00																													
Proposed 3 Storey	Area (m2)	954144,39					318262,50					0,334	239033,25					0,751	173931,75					0,547	191216,25					0,601	Area (m2)	0,558	0,751	0,334
	954144,39	Perimeter (m)	3971,5					2566,00				0,646		2092,00				0,815		1830,50				0,713		1830,50				0,713	Perimeter (m)	0,722	0,815	0,646
		3971,5	TRL (m)	32266,82					13350,50			0,414			8606,25			0,645			6417,50			0,481			6930,50			0,519	TRL (m)	0,515	0,645	0,414
			32266,82	TRCA (m2)	211967,00					70472,50		0,332				52921,75		0,751				38515,75		0,547				42106,75		0,597	TRCA (m2)	0,557	0,751	0,332
				211967,00	Infrastructure Length	30246,94					9871,75	0,326					7536,50	0,763					5433,75	0,550					5871,25	0,595	Infrastructure Length	0,559	0,763	0,326
					30246,94																													
Increase rate	1,125	1,052	1,047	1,046	0,981		1,125	1,037	1,230	1,047	0,909		1,125	1,046	1,047	1,047	0,917		1,125	1,046	1,047	1,047	0,886		1,132	1,050	1,051	1,051	0,890					
4 Storey	Area (m2)						245165,75						183752,00					0,750	133694,00					0,545	134003,00					0,547	Area (m2)	0,614	0,750	0,545
		Perimeter (m)						2068,00						1862,00				0,900		1656,00				0,801		1656,00				0,801	Perimeter (m)	0,834	0,900	0,801
			TRL (m)						8681,00						6641,00			0,765			4948,50			0,570			4954,50			0,571	TRL (m)	0,635	0,765	0,570
				TRCA (m2)						72646,50						54245,00		0,747				39144,75		0,539				39201,75		0,540	TRCA (m2)	0,608	0,747	0,539
					Infrastructure Length						8681,00						6641,00	0,765					4948,50	0,570					4954,50	0,571	Infrastructure Length	0,635	0,765	0,570
Proposed 4 Storey	Area (m2)						272538,62						204268,00					0,750	148621,00					0,545	148964,50					0,547	Area (m2)	0,614	0,750	0,545
		Perimeter (m)						2171,50						1942,50				0,895		1713,50				0,789		1713,50				0,789	Perimeter (m)	0,824	0,895	0,789
			TRL (m)						9072,00						6934,75			0,764			5161,25			0,569			5167,25			0,570	TRL (m)	0,634	0,764	0,569
				TRCA (m2)						75869,37						56653,25		0,747				40892,75		0,539				40949,75		0,540	TRCA (m2)	0,608	0,747	0,539
					Infrastructure Length						7976,50						5863,12	0,735					4041,87	0,507					4047,87	0,507	Infrastructure Length	0,583	0,735	0,507
Increase rate							1,112	1,050	1,045	1,044	0,919		1,112	1,043	1,044	1,044	0,883		1,112	1,035	1,043	1,045	0,817		1,112	1,035	1,043	1,045	0,817					
5 Storey	Area (m2)						303240,00						231648,00					0,764	186960,00					0,617	212895,00					0,702	Area (m2)	0,694	0,764	0,617
		Perimeter (m)						2318,00						2310,00				0,997		2096,00				0,904		2170,00				0,936	Perimeter (m)	0,946	0,997	0,904
			TRL (m)						10284,00						7670,00			0,746			6464,00			0,629			7271,00			0,707	TRL (m)	0,694	0,746	0,629
				TRCA (m2)						109560,00						78180,00		0,714				64992,00		0,593				74232,00		0,678	TRCA (m2)	0,661	0,714	0,593
					Infrastructure Length						10284,00						7670,00	0,746					6464,00	0,629					7271,00	0,707	Infrastructure Length	0,694	0,746	0,629
Proposed 5 Storey	Area (m2)						333830,00						255016,00					0,764	205820,00					0,617	234371,25					0,702	Area (m2)	0,694	0,764	0,617
		Perimeter (m)						2398,50						2367,50				0,987		2142,00				0,893		2227,50				0,929	Perimeter (m)	0,936	0,987	0,893
			TRL (m)						10731,75						7969,00			0,743			6717,00			0,626			7570,00			0,705	TRL (m)	0,691	0,743	0,626
				TRCA (m2)						114390,00						81423,00		0,712				67752,00		0,592				77475,00		0,677	TRCA (m2)	0,660	0,712	0,592
					Infrastructure Length						9377,50						6836,00	0,729					5302,75	0,565					5948,75	0,634	Infrastructure Length	0,643	0,729	0,565
Increase rate							1,101	1,035	1,044	1,044	0,912		1,101	1,025	1,039	1,041	0,891		1,101	1,022	1,039	1,042	0,820		1,101	1,026	1,041	1,044	0,818					
6 Storey	Area (m2)						296718,75						247156,25					0,833	179437,50					0,605	205671,87					0,693	Area (m2)	0,710	0,833	0,605
		Perimeter (m)						2280,00						2058,00				0,903		1822,00				0,799		1933,00				0,848	Perimeter (m)	0,850	0,903	0,799
			TRL (m)						9249,50						7680,00			0,830			5689,00			0,615			6351,50			0,687	TRL (m)	0,711	0,830	0,615
				TRCA (m2)						117587,75						96439,50		0,820				69281,00		0,589				78082,50		0,664	TRCA (m2)	0,691	0,820	0,589
					Infrastructure Length						9249,50						7680,00	0,830					5689,00	0,615					6351,50	0,687	Infrastructure Length	0,711	0,830	0,615
Proposed 6 Storey	Area (m2)						324016,87						266686,87					0,823	195945,75					0,605	224917,87					0,694	Area (m2)	0,707	0,823	0,605
		Perimeter (m)						2383,50						2124,50				0,891		1879,50				0,789		2002,00				0,840	Perimeter (m)	0,840	0,891	0,789
			TRL (m)						9682,75						7945,50			0,821			5913,75			0,611			6755,25			0,698	TRL (m)	0,710	0,821	0,611
				TRCA (m2)						123119,50						99807,12		0,811				72123,00		0,586				83436,62		0,678	TRCA (m2)	0,691	0,811	0,586
					Infrastructure Length						8522,12						6697,25	0,786					4624,62	0,543					5526,87	0,649	Infrastructure Length	0,659	0,786	0,543
Increase rate							1,092	1,045	1,047	1,047	0,921		1,079	1,032	1,035	1,035	0,872		1,092	1,032	1,040	1,041	0,813		1,094	1,036	1,064	1,069	0,870					
7 Storey	Area (m2)						302600,00						242080,00					0,800	170479,50					0,563	198981,75					0,658	Area (m2)	0,674	0,800	0,563
		Perimeter (m)						2334,00						2062,00				0,883		1913,50				0,820		1913,50				0,820	Perimeter (m)	0,841	0,883	0,820
			TRL (m)						8796,00						7056,00			0,802			5284,00			0,601			5966,00			0,678	TRL (m)	0,694	0,802	0,601
				TRCA (m2)						129693,00						102425,00		0,790				73563,25		0,567				85157,25		0,657	TRCA (m2)	0,671	0,790	0,567
					Infrastructure Length						8796,00						7056,00	0,802					5284,00	0,601					5966,00	0,678	Infrastructure Length	0,694	0,802	0,601
Proposed 7 Storey	Area (m2)						328187,50						262550,00					0,800	188357,50					0,574	221176,25					0,674	Area (m2)	0,683	0,800	0,574
		Perimeter (m)						2426,00						2131,00				0,878		1983,50				0,818		1983,50				0,818	Perimeter (m)	0,838	0,878	0,818
			TRL (m)						9129,50						7320,50			0,802			5514,50			0,604			6243,25			0,684	TRL (m)	0,697	0,802	0,604
				TRCA (m2)						134580,50						106335,00		0,790				76886,75		0,571				89275,50		0,663	TRCA (m2)	0,675	0,790	0,571
					Infrastructure Length						7910,75						5988,25	0,757					4295,75	0,543					4882,62	0,617	Infrastructure Length	0,639	0,757	0,543
Increase rate							1,085	1,039	1,038	1,038	0,899		1,085	1,033	1,037	1,038	0,849		1,105	1,037	1,044	1,045	0,813		1,112	1,037	1,046	1,048	0,818					
8 Storey	Area (m2)						307450,00						243101,00					0,791	169968,00					0,553	198687,50					0,646	Area (m2)	0,663	0,791	0,553
		Perimeter (m)						2366,00						2058,00				0,870		1883,00				0,796		2031,50				0,859	Perimeter (m)	0,841	0,870	0,796
			TRL (m)						8343,00						6714,00			0,805			4857,00			0,582			5673,50			0,680	TRL (m)	0,689	0,805	0,582
				TRCA (m2)						139620,00						110857,50		0,794				76352,25		0,547				90826,12		0,651	TRCA (m2)	0,664	0,794	0,547
					Infrastructure Length						8343,00						6714,00	0,805					4857,00	0,582					5673,50	0,680	Infrastructure Length	0,689	0,805	0,582
Proposed 8 Storey	Area (m2)						331502,75						262119,37					0,791	183265,62					0,553	217937,50					0,657	Area (m2)	0,667	0,791	0,553
		Perimeter (m)						2446,50						2115,50				0,865		1929,00				0,788		2101,50				0,859	Perimeter (m)	0,837	0,865	0,788
			TRL (m)						8639,75						6944,00			0,804			5024,25			0,582			5963,75			0,690	TRL (m)	0,692	0,804	0,582
				TRCA (m2)						144621,75						114781,87		0,794				79165,12		0,547				95803,50		0,662	TRCA (m2)	0,668	0,794	0,547
					Infrastructure Length						7306,12						5746	0,786					3651,87	0,500					4644,12	0,636	Infrastructure Length	0,641	0,786	0,500
Increase rate							1,078	1,034	1,036	1,036	0,876		1,078	1,028	1,034	1,035	0,856		1,078	1,024	1,034	1,037	0,752		1,097	1,034	1,051	1,055	0,819					
average	1,125	1,052	1,047	1,046	0,981		1,102	1,041	1,069	1,043	0,912		1,101	1,035	1,040	1,041	0,882		1,105	1,034	1,042	1,043	0,830		1,111	1,037	1,049	1,052	0,857					
max	1,125	1,052	1,047	1,046	0,981		1,125	1,050	1,230	1,047	0,951		1,125	1,046	1,047	1,047	0,917		1,125	1,046	1,047	1,047	0,908		1,132	1,050	1,064	1,069	0,966					
min	1,125	1,052	1,047	1,046	0,981		1,078	1,034	1,036	1,036	0,876		1,078	1,025	1,034	1,035	0,849		1,078	1,022	1,034	1,037	0,752		1,094	1,026	1,041	1,044	0,817					

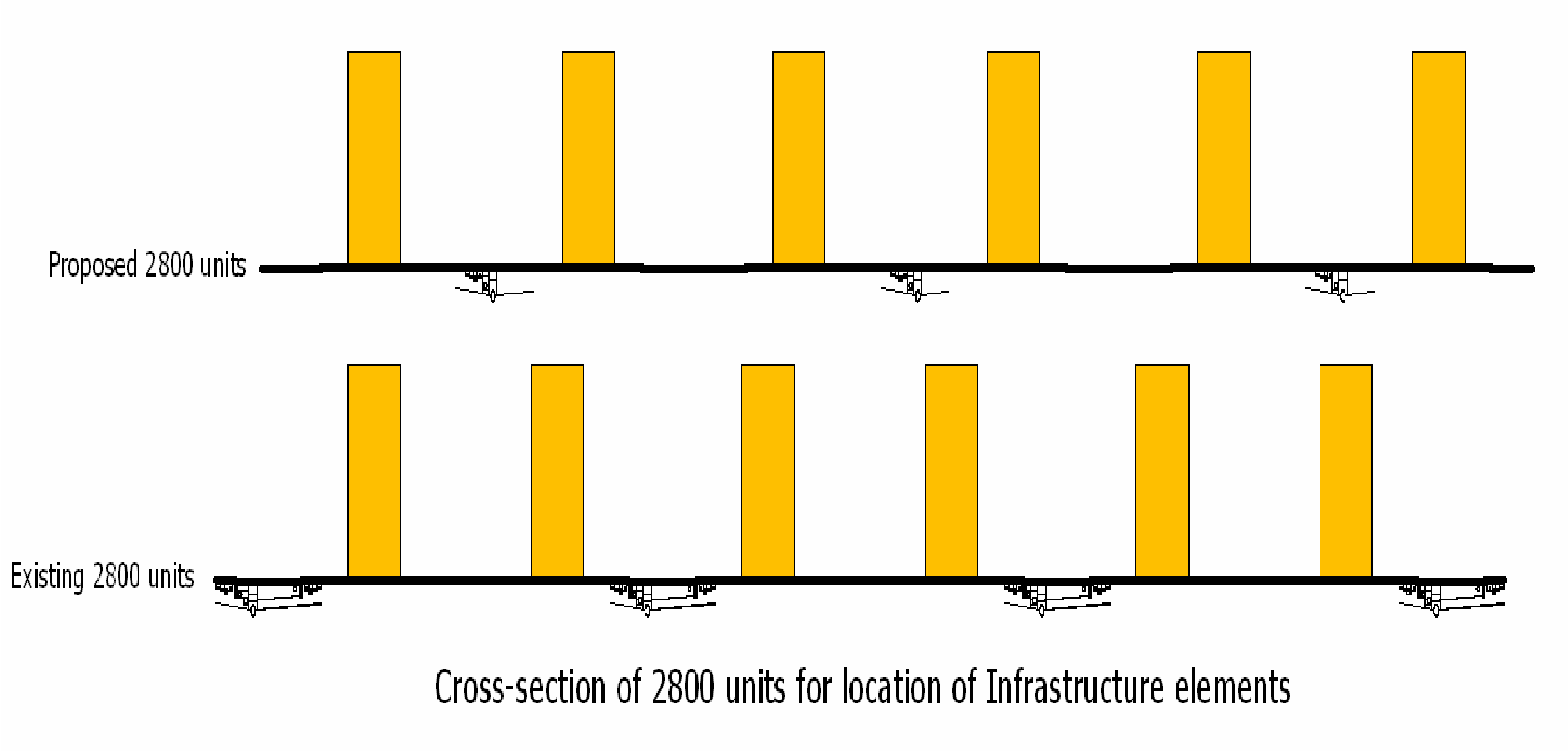


Figure 3.4 Location of Infrastructure elements in 2800 unit neighborhood

3.2 Shorting Length of Roads

3.2.1 Hexagonal Development Pattern

Another alternative to minimizing infrastructure public investment cost is reducing total amount of infrastructure elements under roadways. The likely solution to accomplish this goal is shorting the total length of roadways in urban pattern. Solution was formulated by converting the rectangular conventional shape of residential building block to hexagonal. As developing this kind of solution, problem definition was delineated to define;

- Among all the basic regular geometric shapes having the equal area ($m^{2)}$, which one has the shortest perimeter?

- Regular tessellation that made up of similar regular polygons should cover a plane with a pattern in such a way as to leave no region uncovered, in other words, regular polygons in a tessellation must fill the plane at each vertex. As demonstrated in Figure 3.5

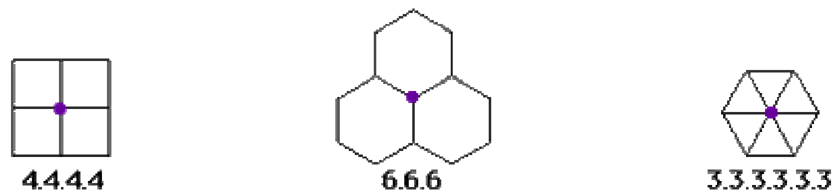


Figure 3.5 Regular Tessellation in Euclidean Plane (Hales 2001)

Although the circle has the least total perimeter, only three regular polygons tessellate in the Euclidean plane: triangles, squares or hexagons. (WEB_2 1995)

Therefore hexagon is the optimum regular polygon as mathematician Thomas C. Hales (2001) has formulated a proof in his article ("The Honeycomb Conjecture) of so called honeycomb conjecture, which holds that a hexagonal grid represents the best way to divide a surface into regions of equal area with the least total perimeter.

Inspiring from honeycomb conjecture, geometric approaches to the planning of cities to achieve economic and efficient pattern of land use structure has been on active debate against the gridiron pattern from the beginning of 20th century.

Several planners proposed residential neighborhood designs with street patterns based upon hexagonal blocks in the early 20th century. Urban designers such as Charles Lamb, Noulan Cauchon and Barry Parker demonstrated the economic advantages and efficient land use generated by hexagonal plans, but such idealized geometrical pattern for residential development plans remained theoretical utopia. (Joseph and Gordon 2000)

Such kinds of necessity of reform against the gridiron pattern began with the modern urban planning movement beginning around the turn of the 20th century; because it was regarded as monotonous, excessively paved and open to through traffic. Another disadvantage of the rectangular grid is the difficulty of diagonal movements, which produce long distance urban trips. Urban designers often attempted to combine diagonal boulevards on a grid background, following the example of L'Enfant's plan for Washington, DC (1793), or CerdaÂ 's plan for the Barcelona Ensanche (1864) (Joseph and Gordon 2000).

Hexagonal plans were advocated by a New York architect and a Viennese engineer during the first decade of the 20th century. The New York architect and art historian Charles Lamb prepared a hexagonal plan in 1904. (See Figure 3.6)

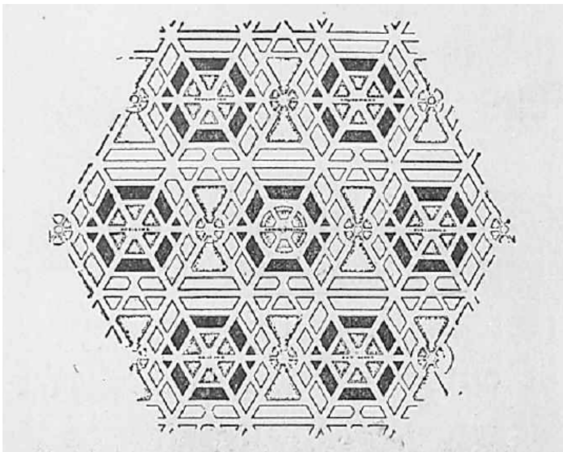


Figure 3.6 Hexagonal Plan Charles Lamb, 1904
(Source: Joseph and Gordon 2000, p.229)

An Austrian engineer, Rudolf Muller claims that the idea of the hexagonal building concept efficient system for water engineering and sewage engineering and especially as a hygienic and nature-friendly system for public and private gardens in the city. Muller drew a diagram of typical hexagonal city blocks and streets and laid out a system of utilities to prove his point. Through geometrical configurations and measurements, he pointed to the potential savings in the length of the water lines as well as those for the sewer system. Fewer fire hydrants and water mains could serve a larger number of buildings, and shorter service lines could be laid between the mains and the buildings (Joseph and Gordon 2000).

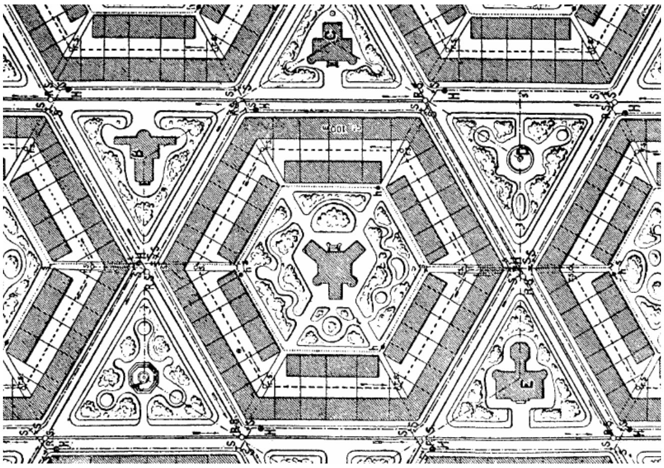


Figure 3.7 Hexagonal Plan, Rudolph Müller, 1908
(Source: Joseph and Gordon 2000, p.235)

In 1925, Noulan Couchon showed the advantages of hexagonal development pattern for residential blocks with a scientific approach to planning. Cauchon revealed his basic hexagonal plan at the 1925 International Town, City and Regional Planning Conference in New York. He compared similarly sized rectangular and hexagonal blocks in detail. The hexagon required 10% less length of roads and utilities and allowed a substantial central green space in each block. (See Figure 3.8) A three-way intersection is theoretically greatly superior to a four-way intersection because the 120° angle has improved sight lines compared with the right angle. The three-legged intersection has only three potential collision points, compared with 16 in the other. (See Figure 3.9)

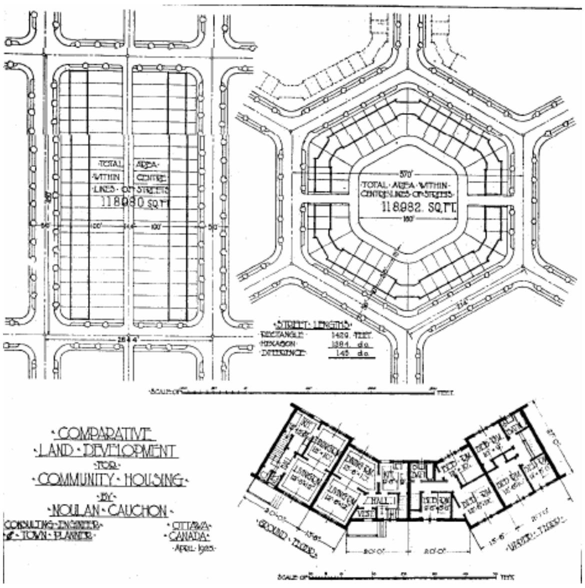


Figure 3.8 Hexagonal Block, Noulan Cauchon, 1925

(Source: Joseph and Gordon 2000, p.246)

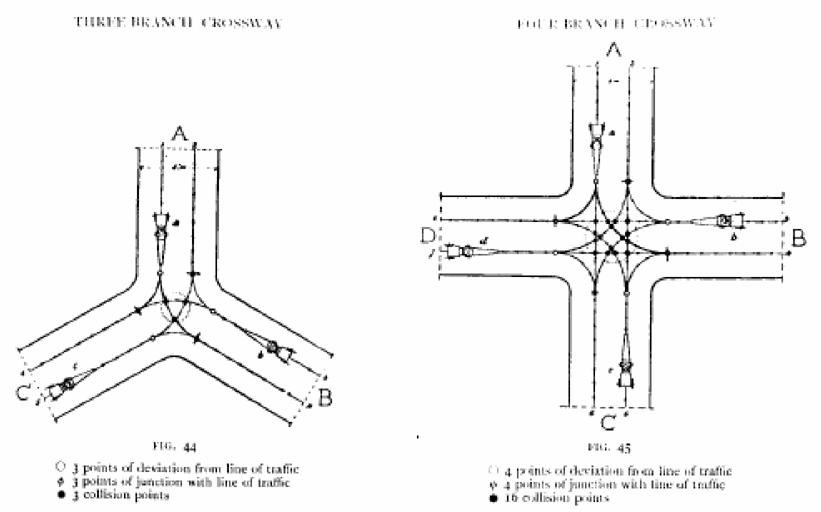


Figure 3.9 Traffic Collision Points for Intersection Type

(Joseph and Gordon, 2000, p.250).

In addition to engineering and planning benefits, Cauchon also suggested that the hexagonal system had public health benefits. If the hexagonal grid was oriented so that it pointed due north, there would never be buildings with a northern exposure, and all rooms in the block would receive direct sunlight every day. However, despite Cauchon's scientific analysis of his plan, not a single hexagon had been built in North America by 1930 (Joseph and Gordon 2000).

After the release of the New York Regional Plan in 1929, Thomas Adams particularly concerned with inefficient and wasteful practices of subdivision plans. Adams, together with Robert Whitten, the president of the American City Planning Institute, conducted an economic study, which compared and analyzed different residential designs. Their analysis concentrated on ratios and costs associated with different physical factors such as densities, lot layouts, utilities, street widths and landscaping. The hexagonal plan could not be rejected on economic or efficiency grounds since Barry Parker's hexagonal layout actually proved to be the most efficient on these criteria (Joseph and Gordon 2000).

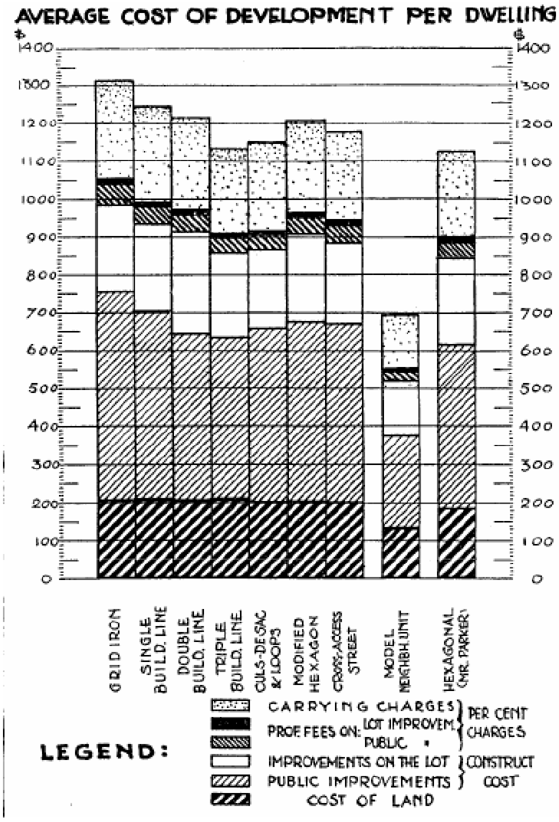


Figure 3.10 Cost of Neighborhood Design Types

(Source: Joseph and Gordon 2000, p.259)

To make absolutely certain that the cul-de-sac and loops scheme was regarded as the most economically efficient, higher-density building types, including townhouses and apartments, were added to make the model neighborhood unit. This denser design was dramatically more cost-efficient, almost 38% cheaper than Parker's hexagonal layout (Joseph and Gordon 2000).

At last, in 1932, Subdivision layout subcommittee of President Hoover's Conference which was the largest ever held by the federal government up to that time on Home Building and Home Ownership was established to set new standards and regulations. Using Adams' comparative diagrams and charts, it authorized the neighborhood unit principle and the interior cul-de-sac as the most economical configuration for residential design. Although the committee suggest the modified hexagonal pattern as one of the most attractive schemes, it also criticized the regular hexagon block as an unfavorable pattern The committee wrote: Although there is no doubt that the hexagon may be used in certain cases with advantage, the practical difficulty of its application for low-cost developments is that it produces a large number of odd shaped lots. President Hoover's conference destroys confidence in hexagonal layouts, and the model neighborhood unit of cul-de-sac and loops was subsequently adapted in government site planning manuals in Northern America. Cauchon's death in 1935 and the chaos of World War II practically put an end to the hexagonal planning (Joseph and Gordon 2000).

After summarizing the chronologically reviewed various hexagonal planning schemes related with its benefits of service cost, for giving a proof to the hexagonal building block's saving figures traditional rectangular building block that shaped by Turkish "*Model Building by-law*" was compared with hexagonal building block, which has the equal area, in terms of perimeter (m). As a result, hexagonal building block provides 8% decrease in terms of diameter. (See Figure 3.11) Additionally, that figure also means 8% reduced total road length and also infrastructure investment cost.

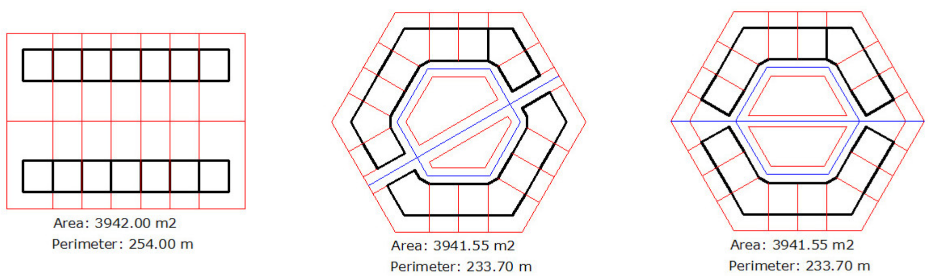


Figure 3.11 Comparison Between Hexagonal and Rectangular Building Blocks

After a micro-scale statistical comparison for single residential building block, the similar comparison is performed again between rectangular and hexagonal residential neighborhood that formed with 2800 dwellings in terms of;

- total area (m^2)

- perimeter (m)

- total road length (m)

- total road coverage area see table 3.3.

Three alternatives developed against traditional development pattern. One of them is identical with traditional development pattern the way building blocks getting together. The other alternatives form total neighborhood in a compact way in order to reduce the perimeter of the entire development. 90 degree rotated form of single hexagonal building block figure out the last alternative development pattern of hexagonal shape. For each alternatives and traditional development pattern various location alternatives for infrastructure elements developed (See Figure 3.15, 3.16, 3.17, 3.18).

At this stage, it is realized that amongst the entire development patterns and their proposed alternatives for 2800 units, proposal 1 for hexagonal development has the maximum decrease rate of road length, area and perimeter, % 10.3, %3.7, % 4.4 respectively. Because, proposal 1 is comprised of 90 degree rotated form of hexagonal residential building units and additionally, it has the most compact form that is similar to single hexagonal building block shape. Therefore, optimum development pattern with hexagonal building blocks is described as in Figure 3.12

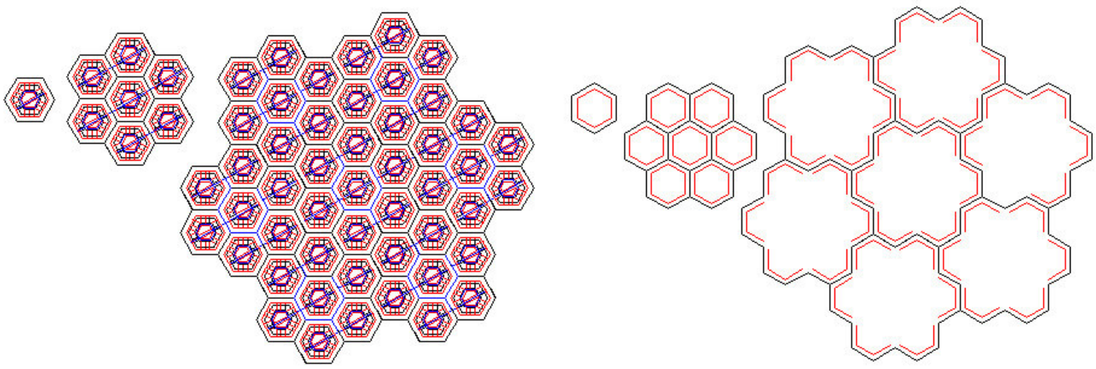


Figure 3.12 Optimum Hexagonal Development Patterns

Although hexagonal development patterns has many advantages like summarized previous section, the critics generally focus on inappropriate orientation and navigation, uncomfortable driving for drivers and odd lots shape. However, all considered drawbacks can be healed by urban design implementation strategies and principles. For this reason new urban development pattern for future development can be described as superimposed pattern of hexagonal and gridiron development pattern. All critics about hexagonal pattern can be resolved by integrating transportation and orientation abilities of gridiron layout of urban structure. So this pattern can be illustrated as in Figure 3.13. While traffic routes of hexagonal pattern will be used for lateral traffic routes, pedestrian routes and location place of all infrastructure elements within the proposed pattern, main transportation routes will be used on gridiron pattern. It means transportation and infrastructure network structure, can be design separately. By doing this, general stress on transportation network, used as circulation area for services and goods, would be shared by both network areas.

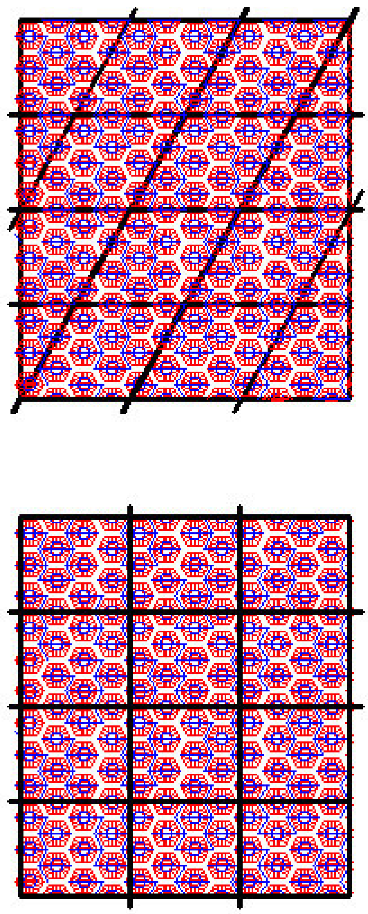


Figure 3.13 Alternative Development Patterns for Hexagonal Layout

Produced alternative solutions for location of infrastructure elements against rectangular development pattern that is described below was applied and compared with hexagonal development alternatives in table 3.3.

- Provided that accepting the whole unit as a single sub-district, providing service utilities solely for 2800 units, (See Figure 3.16, 3.17)

- Creating micro-scale grouping units (vertically or diagonally) in the 2800 units. (See Figure 3.18)

So, combination of such a unified residential development districts of 2800 dwellings figure out the macro form of the total development.

Compared to traditional development pattern, all proposed alternatives with hexagonal development pattern (proposal 1, 2, 3) decrease total infrastructure length. Provided that all infrastructure elements are located under the roadways, decrease rate varied 10.3%, 5.3% and 6.3% for proposal 1, 2, 3 respectively. Proposal 1 seems to be most efficient alternative in terms of total perimeter, land consumption and total length of infrastructure.

On the contrary, if infrastructure elements are located under the centerline of building blocks, total infrastructure length starts to increase surprisingly. Results of vertical and diagonal micro-scale grouping are not different all too much from previous comparisons; % 10.1 and %9.9 increase rate for each alternative. For such kind of solution, (if infrastructure elements are not located under roadways) hexagonal development pattern and its alternative applications are not economic and efficient applications in terms of infrastructure investment cost. So, hexagonal development pattern can be applied just for the location of infrastructure elements under the roadways.

At last, with respect to total number of collision points and total number of junction for both type of development pattern of 2800 dwellings, hexagonal development pattern for residential neighborhood has great advantage against traditional gridiron development pattern. For 2800 units, while hexagonal pattern has 48 3-branch crossway and 144 collision points, traditional gridiron pattern has 16 3-branch crossways, 16 4-branch crossways and totally 304 collision points. Although hexagonal development patterns has many advantages like summarized previous section, the critics generally focus on inappropriate orientation and navigation, uncomfortable driving for drivers and odd lots shape. However, all considered drawbacks can be healed by urban design implementation strategies and principles. For this reason new urban development pattern for future development can be described as superimposed pattern of hexagonal and gridiron development pattern. All critics about hexagonal pattern can be resolved by integrating transportation and orientation abilities of gridiron layout of urban structure. So this pattern can be illustrated as in Figure 3.13. While traffic routes of hexagonal pattern will be used for lateral traffic routes, pedestrian routes and location place of all infrastructure elements within the proposed pattern, main transportation routes will be used on gridiron pattern. It means transportation and infrastructure network structure, can be design separately. By doing this, general stress on transportation network, used as circulation area for services and goods, would be shared by both network areas.

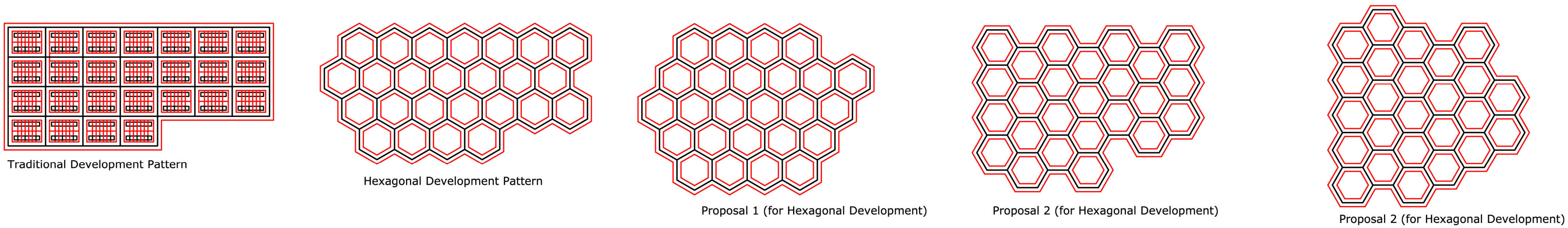


Figure 3.14. Location of Services within the Traditional Gridiron Pattern and Hexagonal Patterns for 2800 units

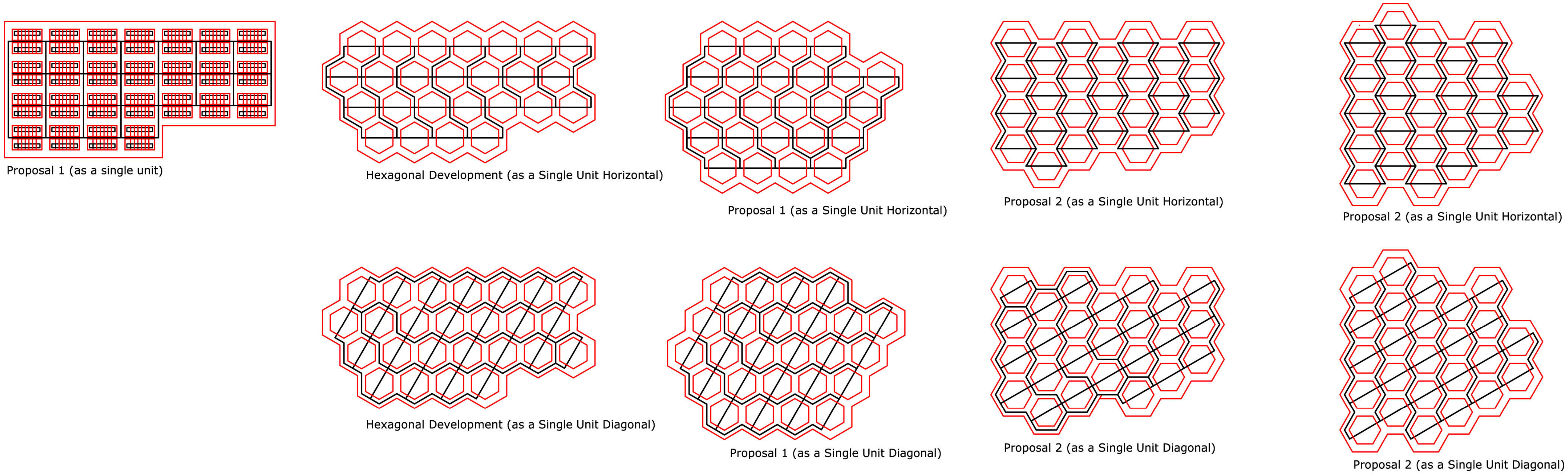


Figure 3.15. Proposal 1 for alternative Location of Services within the Traditional Gridiron Pattern and Hexagonal Patterns for 2800 units.

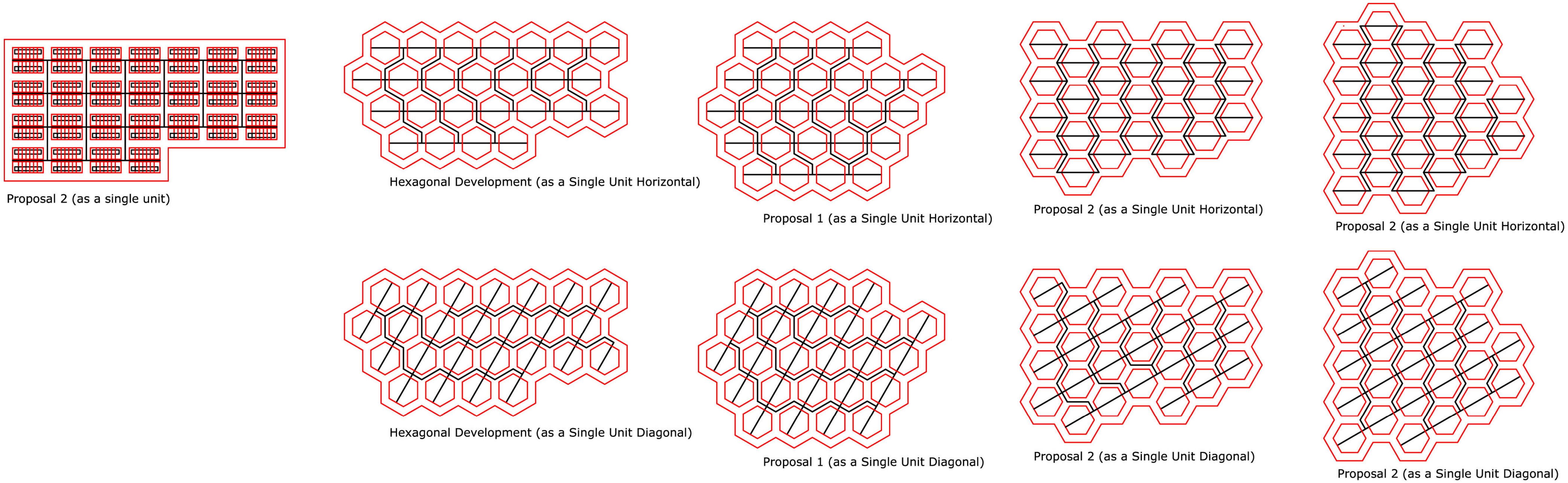


Figure 3.16. Proposal 2 for alternative Location of Services within the Traditional Gridiron Pattern and Hexagonal Patterns for 2800 units.

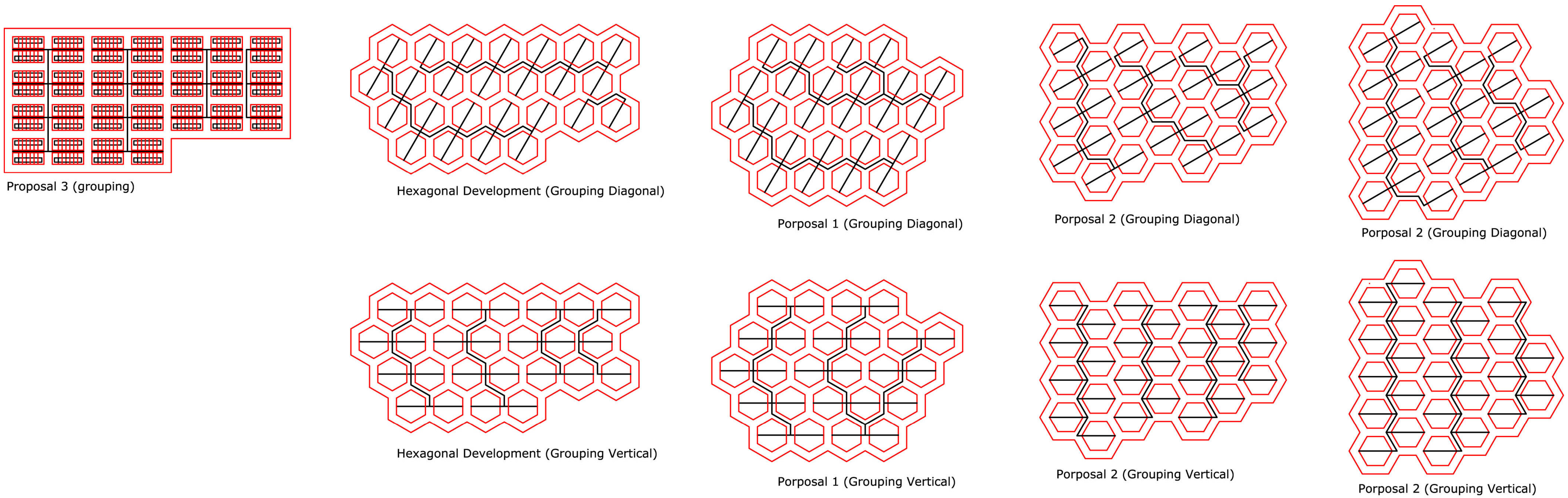


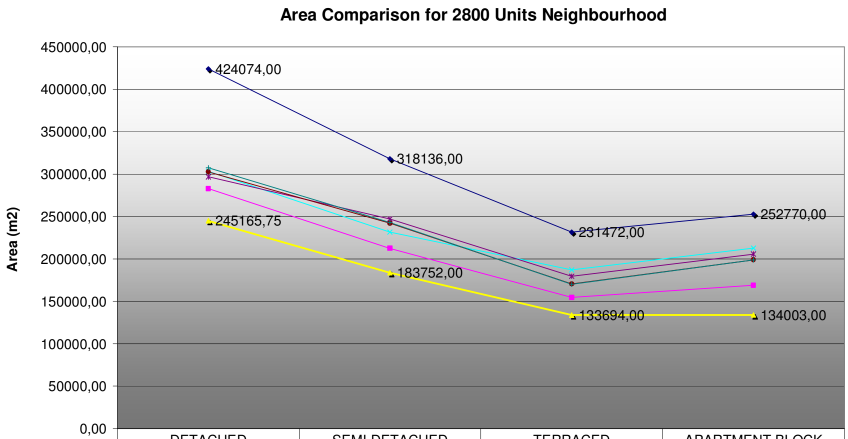
Figure 3.17. Proposal 3 for alternative Location of Services within the Traditional Gridiron Pattern and Hexagonal Patterns for 2800 units.

Table 3.3.Comparative Analysis of Alternative Development Patterns for 2800 Hexagonal DwellingNeighborhood

								Number of Junction		
	Area (m2)	**Decr. Rate based to Traditional Dev.**	**Perimeter (m)**	**Decr. Rate based to Traditional Dev.**	**Total Infrastr. Length (m)**	**Decr. Rate based to Traditional Dev.**	**Area Decr. Rate Within the Proposed Alternatives**	**4 Branch**	**3 Branch**	**Total**
Traditional Development Pattern	188708,25		1961		5091,5			**16**	**16**	**32**
Proposal 1 (as a Single Unit)	202453,63		2007		3976,75		0,781			
Proposal 2 (as a Single Unit 2)	202453,63		2007		3423,25		0,672			
Proposal 3 (Grouping)	202453,63		2007		2861,25		0,562			
Hexagonal Development Pattern	182010,30	0,965	2059,41	1,050	4769,79	0,937	1,000		**48**	**48**
Hexagonal Development (as a Single Unit Horizontal)	182010,30	0,899	2059,41	1,026	4282,83	1,077	0,898			
Hexagonal Development (as a Single Unit Diagonal)	182010,30	0,899	2059,41	1,026	5086,16	1,279	1,066			
Hexagonal Development (as a Single Unit Horizontal 2)	182010,30	0,899	2059,41	1,026	3606,48	1,054	0,756			
Hexagonal Development (as a Single Unit Diagonal 2)	182010,30	0,899	2059,41	1,026	3534,08	1,032	0,741			
Hexagonal Development (Grouping Diagonal)	182010,30	0,899	2059,41	1,026	3034,92	1,061	0,636			
Hexagonal Development (Grouping Vertical)	182010,30	0,899	2059,41	1,026	3034,92	1,061	0,636			
Proposal 1 (for Hexagonal Development)	181688,00	**0,963**	1875,05	**0,956**	4568,95	**0,897**	1,000		48	48
Proposal 1 (as a Single Unit Horizontal)	181688,00	0,897	1875,05	0,934	4634,29	1,165	1,014			
Proposal 1 (as a Single Unit Diagonal)	181688,00	0,897	1875,05	0,934	4885,33	1,228	1,069			
Proposal 1 (as a Single Unit Horizontal 2)	181688,00	0,897	1875,05	0,934	3733,46	1,091	0,817			
Proposal 1 (as a Single Unit Diagonal 2)	181688,00	0,897	1875,05	0,934	3688,85	1,078	0,807			
Proposal 1 (Grouping Diagonal)	181688,00	0,897	1875,05	0,934	3009,81	1,052	0,659			
Proposal 1 (Grouping Vertical)	181688,00	0,897	1875,05	0,934	3110,23	1,087	0,681			
Proposal 2 (for Hexagonal Development)	184625,34	0,978	2176,29	1,110	4819,99	0,947	1,000		48	48
Proposal 2 (as a Single Unit Horizontal)	184625,34	0,912	2176,29	1,084	4870,21	1,225	1,010			
Proposal 2 (as a Single Unit Diagonal)	184625,34	0,912	2176,29	1,084	5186,58	1,304	1,076			
Proposal 2 (as a Single Unit Horizontal 2)	184625,34	0,912	2176,29	1,084	4289,32	1,253	0,890			
Proposal 2 (as a Single Unit Diagonal 2)	184625,34	0,912	2176,29	1,084	3573,08	1,044	0,741			
Proposal 2 (Grouping Diagonal)	184625,34	0,912	2176,29	1,084	3383,75	1,183	0,702			
Proposal 2 (Grouping Vertical)	184625,34	0,912	2176,29	1,084	3110,23	1,087	0,645			
Proposal 3 (for Hexagonal Development)	182667,22	0,968	1975,46	1,007	4769,79	0,937	1,000		48	48
Proposal 3 (as a Single Unit Horizontal)	182667,22	0,902	1975,46	0,984	4970,62	1,250	1,042			
Proposal 3 (as a Single Unit Diagonal)	182667,22	0,902	1975,46	0,984	4584,08	1,153	0,961			
Proposal 3 (as a Single Unit Horizontal 2)	182667,22	0,902	1975,46	0,984	4216,59	1,232	0,884			
Proposal 3 (as a Single Unit Diagonal 2)	182667,22	0,902	1975,46	0,984	3462,91	1,012	0,726			
Proposal 3 (Grouping Diagonal)	182667,22	0,902	1975,46	0,984	3383,75	1,183	0,709			
Proposal 3 (Grouping Vertical)	182667,22	0,902	1975,46	0,984	3135,33	1,096	0,657			

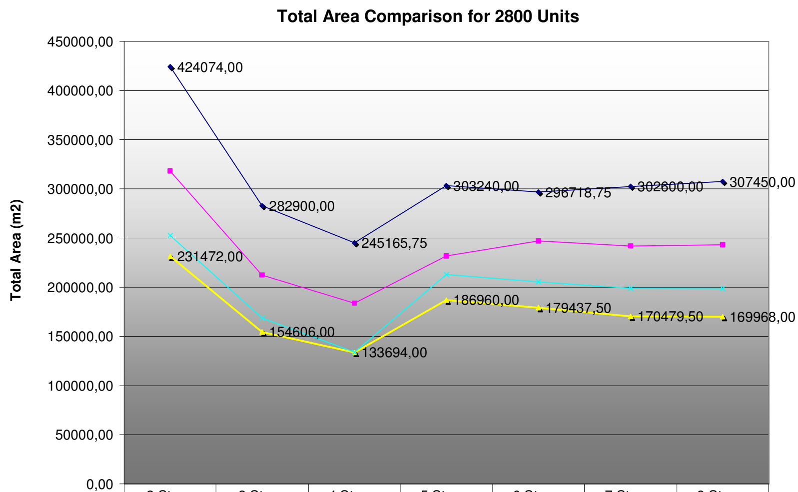
3.2.2 High Density Development Pattern

Another alternative solution to minimizing public infrastructure investment cost is intensive urban development pattern. Using different building types and number of storey decisions that described with Turkish “model building by-law” urban settlement density decisions can be turned into more intensive structure. By doing this, total amount of road length related with infrastructure length and road coverage area values compared for 2800 units residential neighborhood with various density decisions.



	DETACHED	SEMI-DETACHED	TERRACED	APARTMENT BLOCK
2 storey 2800 units	424074,00	318136,00	231472,00	252770,00
3 storey 2800 units	282900,00	212474,00	154606,00	168912,00
4 storey 2800 units	245165,75	183752,00	133694,00	134003,00
5 storey 2800 units	303240,00	231648,00	186960,00	212895,00
6 storey 2800 units	296718,75	247156,25	179437,50	205671,87
7 storey 2800 units	302600,00	242080,00	170479,50	198981,75
8 storey 2800 units	307450,00	243101,00	169968,00	198687,50

BuildingType

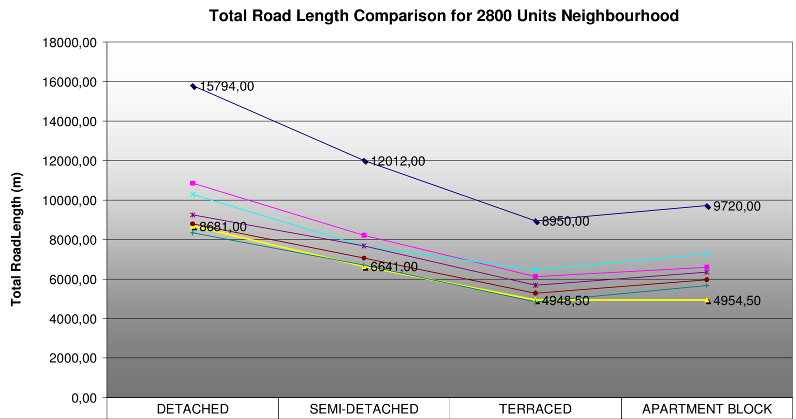


	2 Storey	3 Storey	4 Storey	5 Storey	6 Storey	7 Storey	8 Storey
detached 2800 units	424074,00	282900,00	245165,75	303240,00	296718,75	302600,00	307450,00
semi-detached 2800 units	318136,00	212474,00	183752,00	231648,00	247156,25	242080,00	243101,00
terraced 2800 units	231472,00	154606,00	133694,00	186960,00	179437,50	170479,50	169968,00
apartment block 2800 units	252770,00	168912,00	134003,00	212895,00	205671,87	198981,75	198687,50

Number of Storey

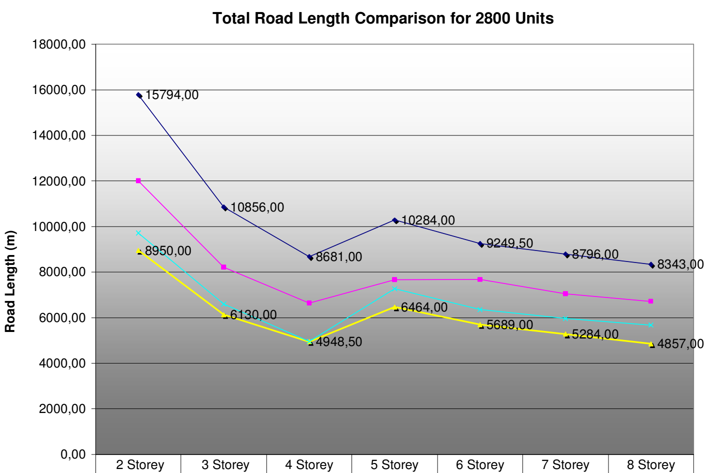
Figure 3.18 Total Area Comparison for 2800 Units

In terms of land consumption total area comparison has been carried out. As expected 2 storeys detached type of development has max values. But, 3 storey and especially 4 storey surprisingly indicate more efficient land consumption amongst the all building types that consider number of storey. At the point of 5 storey all type developments have sharp increase. 4 storey terraced type development has maximum amount of land saving. However, compared to proposed type of development 2 storey, maximum increase rate for coverage area (m2) is 12.5% for 2 storey; minimum increase rate is 7.8% for 8 storey of existing development pattern. That’s why 4 storey terraced type development pattern for residential areas is the most efficient development pattern in terms of land consumption.



	DETACHED	SEMI-DETACHED	TERRACED	APARTMENT BLOCK
2 storey 2800 units	15794,00	12012,00	8950,00	9720,00
3 storey 2800 units	10856,00	8221,00	6130,00	6596,00
4 storey 2800 units	8681,00	6641,00	4948,50	4954,50
5 storey 2800 units	10284,00	7670,00	6464,00	7271,00
6 storey 2800 unit	9249,50	7680,00	5689,00	6351,50
7 storey 2800 units	8796,00	7056,00	5284,00	5966,00
8 storey 2800 units	8343,00	6714,00	4857,00	5673,50

BuildingType

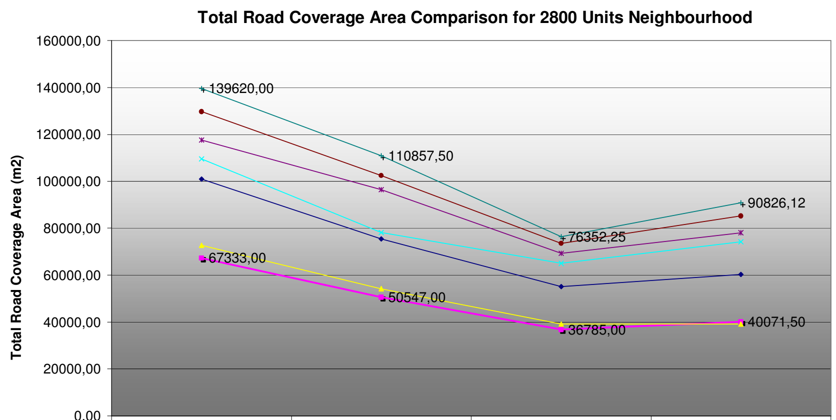


	2 Storey	3 Storey	4 Storey	5 Storey	6 Storey	7 Storey	8 Storey
detached 2800 units	15794,00	10856,00	8681,00	10284,00	9249,50	8796,00	8343,00
semi-detached 2800 units	12012,00	8221,00	6641,00	7670,00	7680,00	7056,00	6714,00
terraced 2800 units	8950,00	6130,00	4948,50	6464,00	5689,00	5284,00	4857,00
apartment block 2800 units	9720,00	6596,00	4954,50	7271,00	6351,50	5966,00	5673,50

Number of Storey

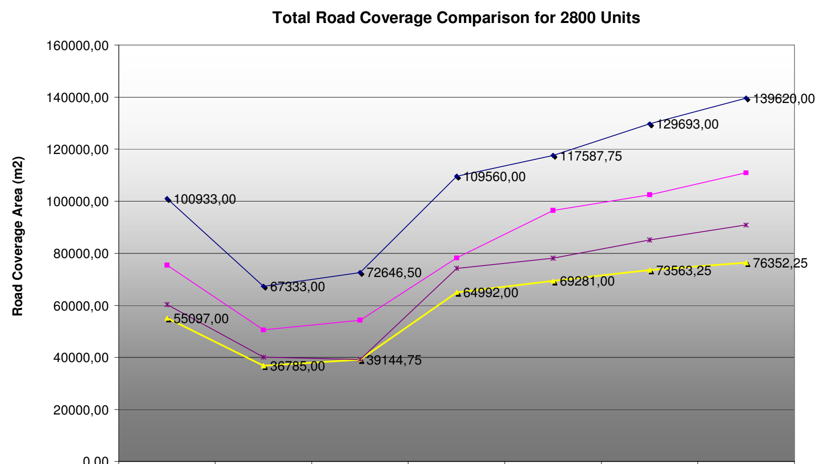
Figure 3.19 Total Road Length Comparison for 2800 Units

In terms of total road length comparison, except for 4 storey development pattern, all development patterns have expected values. Amongst the other type of buildings terraced type development has minimum total road length. Detached types for all storey options have maximum values. Apartment block and terraced types have minimum road length. But, for 4 storey terraced building type again has minimum values of total length of roads. For terraced and apartment blocks type of development, 5 storey values are higher than 3 storey. Compared to proposed type of development, maximum increase rate for total road length (m) is 6.4% for 6 storey blocks type, minimum increase rate is 3.4% for 8 storey terraced of existing development pattern.



	DETACHED	SEMI-DETACHED	TERRACED	APARTMENT BLOCK
2 storey 2800 units	100933,00	75425,00	55097,00	60291,00
3 storey 2800 units	67333,00	50547,00	36785,00	40071,50
4 storey 2800 units	72646,50	54245,00	39144,75	39201,75
5 storey 2800 units	109560,00	78180,00	64992,00	74232,00
6 storey 2800 units	117587,75	96439,50	69281,00	78082,50
7 storey 2800 units	129693,00	102425,00	73563,25	85157,25
8 storey 2800 units	139620,00	110857,50	76352,25	90826,12

BuildingType



	2 Storey	3 Storey	4 Storey	5 Storey	6 Storey	7 Storey	8 Storey
detached 2800 units	100933,00	67333,00	72646,50	109560,00	117587,75	129693,00	139620,00
semi-detached	75425,00	50547,00	54245,00	78180,00	96439,50	102425,00	110857,50
terraced 2800 units	55097,00	36785,00	39144,75	64992,00	69281,00	73563,25	76352,25
apartment block	60291,00	40071,50	39201,75	74232,00	78082,50	85157,25	90826,12

Number of Storey

Figure 3.20 Total Road Coverage Area Comparison for 2800 Units

In terms of number of storey, while 3 storey development patterns has minimum values of total road coverage area, 8 storey development pattern has maximum values surprisingly because of its road width value. Comparing to building types, terraced 3 storey building types has the minimum value. Compared to proposed development type, maximum increase rate for total road coverage area (m2) is 6.9% for 6 storey apartment block type; minimum increase rate is 3.5% for 8 storey semi-detached of existing development pattern. Although 2 or 3 storey development pattern of residential areas have maximum road length, they have minimum values of total land consumption for roads. Besides its values 4 storey terraced type development still the most efficient development pattern.

Compared to proposed type of developments, existing development pattern has a maximum decrease rate for total infrastructure length is 24.8% for 8 storey terraced type of building and minimum increase rate is 2.0% for 2 storey detached duplex building type.

For 2800 unit residential area, according to "*model building by-law regulations*", 9.30 m road width refers four storey development types. Up to this road width (provided that roadways are used for infrastructure location), infrastructure length decrease rate for 2800 units is just 13.4% for proposed building block type, because every infrastructure elements are located once under roadways and sidewalks. However, for 5,6,7,8 storey that decrease rate means 113.4% because all infrastructure elements are located once in 5.75 m width public space instead of locate under roadways for both side.

According to TS1097 minimum sidewalk width should be 5.50 m, if vegetation elements will be located on the same sidewalk. It means sidewalk width for 4 numbers of utilities (Electricity; 0.80m, Telecommunication; 0.85m, Lateral Water Supply; 0.70 m, Lateral Gas pipe; 0.70 m) increase from 3.05 m to 5.50 m in width. At this point 5.75 m in width public space for utilities that located on the centerline of the building block will be more significant and efficient application for future urban development. Minimum 5.75 m width public space for urban technical infrastructure elements should be used as pedestrian or green network...etc. for entire settlement pattern.

This type of development has many advantages;

- Reduced stress on public vehicular roads and sidewalk,
- Reduced maintenance and repair cost ,
- Reduced infrastructure investment cost,

- Reduced social cost,

- 2.75 m and narrower sidewalks become suitable area for vegetation elements.

- Usage of roadways turns in to just for moving public good and circulation channels.

With the proposed type pedestrian circulation that totally separated from vehicular circulation, safety and continuity will be provided for pedestrians. Main pedestrian axes will be used for infrastructure location area at the same time.

After analyzing probable solutions to minimizing public investment cost of urban technical infrastructure, next chapter “compact urban form” as a future development pattern will be examined in detail. Especially, investment cost comparison for residential areas with different density and evaluation of “model building by-law” in terms of land consumption will be statistically analyzed in order to find out its benefits. While searching for the most efficient development pattern for residential areas of urban settlements with respect to public investment cost, critics, disadvantages and advantages of “compact urban form” will be discussed in the chapter 4.

CHAPTER 4

SUSTAINABLE URBAN FORM: COMPACT CITY

After analyzing various urban development decisions that described with "*Model Building by-law*", modifying existing urban structure or creating probable future development areas with using "smart growth", "new urbanism" design principles and guidelines is another alternative to minimize infrastructure investment cost. By doing this it is also achieved that future development areas will be more efficient in order to create sustainable development pattern.

European Sustainable Cities Report (1996) prepared by The Expert Group on the Urban Environment of EU acknowledged as an essential reference for developing macro scale solutions of urban settlements to minimize cost of urban technical infrastructure for public sector. European Sustainable Cities Report implies in many chapters and also declared explicitly that sustainable development form "*Compact City Form*" is the most favorable resolution for cities. Because, at the beginning of the report, the objectives of sustainable development approach; minimizing consumption of natural resources, especially non-renewable and slowly renewable ones; minimizing production of waste by reusing and recycling wherever possible; minimizing pollution of air, soil and waters; and increasing the proportion of natural areas and biodiversity in cities superimposed with the compact city development policies and objectives. Besides the sustainable development objectives, Expert Group advises many design principles to shape urban development pattern. In each thematic chapter mainly it is recommended that;

- The general aim should be an increase in the size of natural areas and their conservation,

- For the matters of transportation and distribution length and potentially dangerous networks should be shortened and made safer through planning and design, because lengthy energy distribution networks acquire increased risk of leakage and energy loss.

- Spatial planning system to attach design and planning to secure significant energy savings. Options such as bio-climatic architectural design, layout, construction materials, insulation techniques, location of activities, densities, orientation of buildings, provision of green structures, microclimate etc. can play an important role in the achievement of increased energy efficiency of urban systems. For example, high density implies lower energy use in buildings, because apartments and townhouses require less energy for heating and cooling than detached single-family houses.

- Cluster type urban built environment is recommended for future development pattern. This type of development requires specific policy measures. For example, the sustainability cluster requires economical land use, which may be addressed by multiple use of land, underground construction or compact building.

- The Green Paper on Urban Environment argues that the "compact city" form is likely to be the most energy efficient as well as having social and economic advantages.

- The Green Paper on the Urban Environment strongly recommends the encouragement of mixed use schemes. Mixed use is an urban form which offers the opportunity for reduction in movement overall.

- Measures to give priority to cycles and pedestrians should be much more seriously considered, as they have clear benefits, principally low capital cost and very limited impact on the environment. In addition, as a large proportion of urban trips are minimized. There is enormous potential to shift these short trips from the car to cycling and walking.

- The general aim in relation to soil, flora and fauna is to increase the proportion of natural and human-made eco-systems within cities.

- In order to achieve sustainable urban development and reducing natural resources usage expert group recommend to collect storm water from roofs of buildings, two separate water supply systems (one carrying drinking water and the other recycled washing water (grey water)) and also separation of waste water into two categories washing water and toilet waste.

Obviously Expert Group state that in terms of development pattern and layout (land use allocation, density, networked structure of technical services (transportation, waste collection, water, electricity, communication…), ecology, environmental quality and energy "*compact city form*" is the most feasible urban development pattern for the future of cities. The main focus of the thesis is minimizing public investment cost of urban technical infrastructure; therefore this chapter mainly focuses on urban macro form and urban technical infrastructure relationship. Besides, compact development form and relative comparison between alternative development patterns have been evaluated.

The macro-form of a town or city can affect its sustainability. It is accepted that relationship between the shape, size, density and land use decisions can also affect cities and its sustainability. However, it is now not clear exact nature of its relationship. Certain urban forms accepted as a sustainable in some respect, for example reducing travel or enable fuel efficiency, but on the other hands that harms environmental quality or produce social inequalities. Additionally some forms may be sustainable locally, but not be beneficial city wide or regionally. At that point main problem is defining "what is sustainable urban form?", "Which urban form achieve sustainable urban development principles and how can it be achieved?" (Williams 2000)

Zoning of different land uses mean that people have to travel longer distances to work, shopping centers and leisure activities. Therefore developed countries faced to "mobility explosion". Over the last several decades many communities have experienced sprawl development pattern, with dispersed, low-density, automobile-dependent urban fringe expansion. This development pattern intensifies many problems, raging from the economic cost to consumers and governments of an automobile-dependent transportation system, to the environmental costs of development that produces lack of green spaces and all have contributed to unsustainability. It is clear that cities in developed countries are not functioning in a sustainable way. They are using more than their needs and producing too much waste.

Clearly urban sustainability is not dependent on urban form alone. Behavior and attitudes are also required. Therefore it can be stated that sustainability is not an end product, but it is a process to achieve. It is investigated that dominant model for urban sustainability is "Compact City". Traditional high density European cities such as Paris and Barcelona are accepted as a sustainable solution for urban form in most countries of the developed world (Williams *et al* 2000).

So far many researches have been performed about compact city form and its benefits. Comparative analysis achieved between alternative development patterns with respect to environmental quality, social equity, transportation, energy consumption and urban technical infrastructure provision. Due to sustainable urban development principles and minimizing urban technical infrastructure investment costs are main concern of the thesis, urban compactness and service cost relationship will be examined in detail for current development patterns of Turkey. In order to achieve this, the study represents a quantitative investigation, comparing, through statistical tests for different density or different housing type will be evaluated in terms of land coverage and service length and costs. But all studies performed for public investment cost that include only initial costs, ongoing incremental costs are excluded.

4.1. Definitions and Indicators of Compact City Form

Before defining to exact definition of Compact City, general approach is to understand the concept of sustainable development and then relate it to urban context. In the Chapter 5 it is widely explained "what is Sustainability and Sustainable urban Development?" therefore just a list of principles for a sustainable built environment that defined by Smith *et al.* (1998) and certain conditions that sustainable urban form should be provided accepted by Williams *et al.* (2000) will be explained as a additional contribution to its definition. Smith *et al.* (1998) explains the principles of sustainable built environment as; living for environmental interest rather than capital, not breaching critical environmental thresholds, developing a sense of equity and social justice and forming inclusive procedures for decision making. According to Williams *et al.* (2000), a form is taken to be sustainable if it enables the city to function within its natural and man-made carrying capacities, is 'user-friendly' for its residents and promotes social equity.

The Compact City Form is offered the most sustainable future, subsequently researches has focused on compact instead dispersed settlement patterns. In terms of shape and structure Newton, (2000) categorized the cities as;

- *Dispersed City*; automobile dependant, low density suburban development pattern,

- *Compact City*; Mixed land-use, high density inner city with population and employment,

- *Edge City*; Interrelated high density population and housing nodes connected with orbital freeways,

- *Corridor City*; concentrated development along the corridors radiate from CBD,

- *Fringe City*; peripheral development pattern on the fringe of the city (Newton, 2000).

Mainly to define and clarify "what is compactness" and to what extent urban settlement accepted as compact, it should be set a series of indicators for urban compactness;

- *High Density*,

-Density of population

-Density of built form

-High density sub-centers (decentralized concentration)

-High density housing forms

- *Mix of Land uses*,

-Provision of facilities

-Horizontal Mix of uses

-Vertical Mix of uses (Burton 2002)

- *Increased Intensification;* is the ratio of population or jobs to area,

Intensification of built environment

-Development of previously undeveloped urban land

-Redevelopment of existing buildings or previously developed sites (where an increase in floor space results)

-Subdivisions and conversions (where an increase in the use of building results)

-Additions and extensions (where an increase in the built densities or an intensification of the use results)

Intensification of activities

-Increased use of existing building or sites

-Change of use

-An increase in numbers of people living in, working in, or traveling through an area (Jenks 2000)

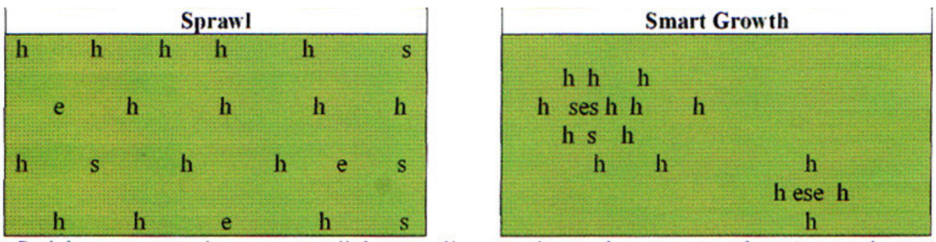
- *Land use connectivity* measures the interrelation and mode of circulation of people and goods the location across the location of fixed activities.

- *Urban concentration* refers to the degree of centralization of the urban structure (Alberti 2000).

Compact city proposed to develop as an efficient land use and transport patterns of urban form does not have a generally accepted definition. Elkin *et.al.* (1991) defined compact city as; a form and scale appropriate to walking, cycling and efficient public transport, and with compactness that encourages social interaction. Compactness Gordon and Richardson (1997) defined urban compact development as high-density or monocentric development. Ewing's definition was concentration of employment, housing and mixed land-use. Conversely, Anderson *et al*. (1996) defined urban compactness both monocentric and polycentric forms. Other descriptions are more measurement-based. Bertaud and Malpezzi (1999) developed a compactness index and its ratio varying between the average distance from home to central business district

(CBD. Galster *et al.* (2001) described compactness as the degree to which development is clustered and minimizes the amount of land developed in each square mile. Despite various definitions, one common theme is the vague concept that compactness involves the concentration of development. Although urban centralization and decentralization refers compactness and dispersed urban development respectively, there is no consensus on polycentric urban development pattern. Because urban compactness generally implies monocentric development pattern.

Smart Growth does not require that a smaller city become a larger city. It requires that for a given population, a town or city develop in ways that increase clustering, connectivity, land use mix and transportation diversity. Two areas can have the same regional density but one reflects Smart Growth and the other does not, as illustrated in Figure 4.1.



Both boxes contain the same overall density of housing (h), employment (e) and services (s), but on the left they are more dispersed and on the right they are more clustered, creating "villages."

Figure 4.1. Sprawl versus Smart Growth Land use Pattern
(Source: Litman 2004, p.14)

Despite a lack of agreement, sprawl is often defined by four land use characteristics: low density, scattered development, commercial strip development, and leapfrog development. (Ewing 1997) As an opposite development pattern compact city and also called "Smart Growth" characterized by population, employment and housing intensification within the inner city. Smart Growth emphasizes accessibility that allows people reach desired goods, services and activities, while sprawl emphasizes mobility (physical movement) and automobility (movement by automobile). Main differences indicated in 4.1.

Table 4.1. Comparing Characteristics of Smart Growth and Sprawl
(Source: Ewing 1996; Galster et al 2001)

	Smart Growth	**Sprawl**
Density	Higher-density, clustered activities.	Lower-density, dispersed activities.
Growth pattern	Infill (brownfield) development.	Urban periphery (greenfield) development.
Land use mix	Mixed land use.	Homogeneous (single-use, segregated) land uses.
Scale	Human scale. Smaller buildings, blocks and roads. Careful detail, since people experience the landscape up close, as pedestrians.	Large scale. Larger buildings, blocks, wide roads. Less detail, since people experience the landscape at a distance, as motorists.
Public services (shops, schools, parks)	Local, distributed, smaller. Accommodates walking access.	Regional, consolidated, larger. Requires automobile access.
Transport	Multi-modal transportation and land use patterns that support walking, cycling and public transit.	Automobile-oriented transportation and land use patterns, poorly suited for walking, cycling and transit.
Connectivity	Highly connected roads, sidewalks and paths, allowing relatively direct travel by motorized and nonmotorized modes.	Hierarchical road network with numerous loops and dead-end streets, and unconnected sidewalks and paths, with many barriers to nonmotorized travel.
Street design	Streets designed to accommodate a variety of activities. Traffic calming.	Streets designed to maximize motor vehicle traffic volume and speed.
Planning process	Planned and coordinated between jurisdictions and stakeholders.	Unplanned, with little coordination between jurisdictions and stakeholders.
Public space	Emphasis on the public realm (streetscapes, pedestrian environment, public parks, public facilities).	Emphasis on the private realm (yards, shopping malls, gated communities, private clubs).

Compact development pattern applies “Smart Growth” and “New Urbanism” development strategies and principles that result in more efficient land use and transport patterns. Smart Growth that defined as a combining a mix of land uses, compact building design, and diverse housing opportunities in compact, walkable communities with a variety of transportation options, and a reliance on participatory planning and predictable decision processes to preserve and strengthen existing settlements and promote a strong sense of place (EPA 2002) tries to finding ways to encourage economic growth while preserving valuable natural resources and environments. Compared to traditional development, new smart growth is more town-centered, is transit and pedestrian oriented, and has a greater mix of housing, commercial and retail uses (International City/County Management Association with Geoff Anderson 1998).

Smart Growth (also called New Urbanism) integrates transportation and land use decisions, for example by encouraging more compact, mixed-use development within existing urban areas, and discouraging dispersed, automobile dependent development at the urban fringe. Smart Growth can help create more accessible land use patterns, improve transport options, create more livable communities, reduce public service costs and achieve other land-use objectives. The debate of Smart Growth reflects *a paradigm shift* (a change in how problems are defined and solutions evaluated), as summarized in Table 4.2.

Table 4.2. Old versus new transport/land use planning paradigm
(Source: Litman 2004,p.11)

Issue	Old	New
Progress	Growth: expanding, getting bigger.	Development: improving, getting more
Goal of transport.	Mobility/Traffic: considers movement an end in itself.	Accessibility: the ability to reach desired goods, services and destinations.
Analysis approach	Reductionist. Considers problems, impacts and solutions individually.	Integrated. Considers problems, impacts and solutions together.
"The" transport problem.	Urban traffic congestion.	There are many significant transport problems.
Roadway function	Traffic flow: values the cheapest way to move the maximum amount of traffic.	Multifunctional: values diverse activities on roads, including walking
Roadway users	Streets are for vehicular traffic.	Streets are for people.
Resident perspective	Residents are mobile consumers who are quick to leave troubled areas and move to a "better" community.	Residents are community members who want to improve existing neighborhood and make their community a better place to
Transportation perspective	Motorist's perspective.	Motorists, transit users, cyclists, pedestrians, residents and businesses.
Role of non-motorized modes.	Usually of little importance. Mainly recreational. Can generally be ignored.	Is critical for system connections, mobility for non-drivers and personal

Smart Growth reflects the new paradigm, which focuses on accessibility, multi-modalism and comprehensive analysis, while Smart Growth criticism tends to reflect the older paradigm which focuses on vehicle traffic conditions. For example, the new paradigm tends to support land use clustering, transit priority and traffic calming, since they improve accessibility, while the old paradigm tends to oppose these strategies because they reduce automobile traffic speeds, and many of the benefits are outside the traditional range of transport planning evaluation.

Ye et al.(2005) summarized the elements of Smart Growth policies as below;

Table 4.3. Main Elements of Smart Growth Policies
(Source: Ye *et.al*. 2005)

1. *Planning* -comprehensive planning, -mixed land uses -street connectivity -Alternative/innovative water infrastructure and systems -public facilities planning
2. *Transportation* -Pedestrianization -Facilities for bicycling -Public transit promotion -Systems integration and nodal networks
3. *Economic Development* -Neighborhood business -Downtown revitalization -Infill development -Using existing infrastructure
4. *Housing* -Multifamily housing -Smaller lots -Manufactured homes -Housing for special needs and diverse households
5. *Community Development* -Popular participation -Recognizing/promoting the unique features of each community
6. *Natural Resource Preservation* -Farmland preservation -Subdivision conservation -Easement conservation -Transferable development right -Purchase of development rights -Historical preservation -Ecological land preservation

4.2. Development Principles and Strategies of Compact City Form

The principles of Smart Growth and New Urbanism can be applied increasingly to projects at the full range of scales from a single building to an entire community. When developing a project wherever it can be implemented urban, suburban or rural area should accommodate the principles below;

Urban: In urban areas it emphasizes redevelopment and infill of existing urban neighborhoods, improving mixed-use design features (such as Traffic Calming of urban streets and Location Efficient Development), and enhancing multi-modal transport systems, particularly walking and public transit.

Suburban: In suburban areas it creates medium-density, mixed-use, multi-modal centers (sometimes called Transit Villages), either by incrementally developing existing suburban communities or by master-plan developments that reflect Smart Growth principles. It encourages more complete suburban communities (more local services and employment in suburban jurisdictions), and improved regional travel options such as ridesharing and transit improvements. It supports greenspace preservation.

Rural: In rural areas Smart Growth involves policies that help channel development and public services into accessible, mixed-use villages (for example, having schools, stores and affordable housing located close together and well connected by good walking facilities), and implementation of rural community TDM.

The principles of New Urbanism explained below;

• *Walkability*

- Most things within a 10-minute walk of home and work,
- Pedestrian friendly street design (buildings close to street; porches, windows & doors; tree-lined streets; on street parking; hidden parking lots; garages in rear lane; narrow, slow speed streets)
- Pedestrian streets free of cars in special cases.

• *Connectivity*

- Interconnected street grid network disperses traffic & eases walking
- High quality pedestrian network and public realm makes walking pleasurable

• *Mixed- use and Diversity*

- A mix of shops, offices, apartments, and homes on site. Mixed-use within neighborhoods, within blocks, and within buildings

- Diversity of people - of ages, classes, cultures, and races

• *Mixed Housing*

- A range of types, sizes and prices in closer proximity

• *Quality Architecture and Urban Design*

- Emphasis on beauty, aesthetics, human comfort, and creating a sense of place; Special placement of civic uses and sites within community. Human scale architecture and beautiful surroundings nourish the human spirit

• *Traditional Neighborhood Structure*

- Discernable center and edge

- Public space at center

- Importance of quality public realm; public open space designed as civic art

- Contains a range of uses and densities within 10-minute walk

- Transect planning: Highest densities at town center; progressively less dense towards the edge. The transect is an analytical system that conceptualizes mutually reinforcing elements, creating a series of specific natural habitats and/or urban lifestyle settings. The Transect integrates environmental methodology for habitat assessment with zoning methodology for community design. The professional boundary between the natural and man-made disappears, enabling environmentalists to asses the design of the human habitat and the urbanists to support the viability of nature. This urban-to-rural transect hierarchy has appropriate building and street types for each area along the continuum.

• *Increased Density*

- More buildings, residences, shops, and services closer together for ease of walking, to enable a more efficient use of services and resources, and to create a more convenient, enjoyable place to live.

- New Urbanism design principles are applied at the full range of densities from small towns, to large cities

• *Smart Transportation*

- A network of high-quality trains connecting cities, towns, and neighborhoods together

- Pedestrian-friendly design that encourages a greater use of bicycles, rollerblades, scooters, and walking as daily transportation

• *Sustainability*

- Minimal environmental impact of development and its operations

- Eco-friendly technologies, respect for ecology and value of natural systems

- Less use of finite fuels

- More local production

- More walking, less driving

• *Quality of Life*

- Taken together these add up to a high quality of life well worth living, and create places that enrich, uplift, and inspire the human spirit. (WEB_3 2004)

Smart Growth includes various implementation strategies but which strategies are appropriate for implementation varies depending on conditions and objectives. Smart Growth is best implemented as an integrated program. For example, increased density, improved walkability or increased transit service because themselves cannot be considered Smart Growth. Smart Growth strategies listed below:

-*Encourage mixed housing types and price;* Develop affordable housing near employment, commercial and transport centers. Encourage secondary suites, apartments over shops, lofts, location-efficient mortgages and other affordable housing innovations.

-*Strategic planning;* Establish a comprehensive community vision which individual land use and transportation decisions should support.

-*Create more self-contained communities;* Reduce average trip distances, and encourage walking, cycling and transit travel, by locating a variety of compatible land uses within proximity of each other. For example, develop schools, shops and recreation facilities in or adjacent to residential areas. Mix land uses at the finest grain feasible.

-*Maximize accessibility and transportation options*; Try to locate associated land uses close together (such as locating schools and commonly-used retail businesses within or next to residential neighborhoods), and support transportation diversity, including walking, cycling, ridesharing, public transit, delivery Services and telework.

-*Create walkable neighborhoods;* Walkability is important for Smart Growth, because it increases community livability and travel options (most transit trips include walking links).

-*Foster distinctive, attractive communities with a strong sense of place;* Encourage physical environments that create a sense of civic pride and community cohesion, including attractive public spaces, high-quality architectural and natural elements that reflect unique features of the community, preservation of special cultural and environmental resources, and high standards of maintenance and repair.

-Encourage quality, compact development; Allow and encourage higher density development, particularly around transit and commercial centers. Reduce minimum lot sizes, building setbacks, minimum parking requirements, and minimum street size. Allow transfer of develop capacity of outlying areas to more centralized areas. Demand high quality designs that address problems associated with higher density.

-*Use Context Sensitive Design*; Foster distinctive communities with a strong sense of place.

-Encourage Cluster development; Keep clusters small and well defined, such as "urban villages" with distinct names and characters. Walkable centers that contain an appropriate mixture of land uses (residential, commercial, institutional, recreational) with distinct names and characters. Reduce minimum lot sizes, building setbacks, minimum parking requirements, and minimum street size particularly around transit and commercial centers.

-Encourage infill development; Reduce average trip distances, and encourage walking, cycling and transit travel, by locating new development in already developed areas, so that activities are close together. Review public costs to insure that public expenditures do not favor new, greenfield development over existing residents or infill development. Encourage redevelopment of older facilities and brownfields.

-Reform tax and utility rate; Structure property taxes, development fees and utility rates to reflect the lower public service costs of clustered, infill development, and focus economic development incentives to encourage businesses to locate in more accessible locations (Smart Growth Policy Reforms).

-*Concentrate activities*; Encourage pedestrian and transit travel by creating "nodes" of high-density, mixed development that are linked by convenient transit service. Concentrate commercial activities in these areas. Retain strong downtowns and central business districts. Use access management to discourage arterial strip commercial development.

-*Encourage Transit Oriented Development*; Increase development density within walking distance (400-800 m) of high capacity transit stations and corridors, and provide high quality pedestrian and cycling facilities in those areas.

-Manage parking for efficiency; Encourage shared parking, and other parking management strategies. Reserve the most convenient parking for rideshare vehicles.

-Avoid overly-restrictive zoning; Reduce excessive and inflexible parking and road capacity requirements. Limit undesirable impacts (noise, smells and traffic) rather

than broad categories of activities. For example, allow shops and services to locate in neighborhoods provided that they are sized and managed to avoid annoying residents.

-Good roadway connectivity; Create a network of well-connected streets and paths, with short blocks and minimal cul-de-sacs. Keep streets as narrow as possible, particularly in residential areas and commercial centers. Use traffic management and traffic calming to control vehicle impacts rather than dead ends and cul de sacs.

-Site design and building orientation; encourage buildings to be oriented toward city streets, rather than set back behind large parking lots. Avoid large areas of parking or other unattractive land uses in commercial areas.

-Improve nonmotorized travel conditions; Encourage walking and cycling by improving sidewalks, paths, crosswalks, protection from fast vehicular traffic, and providing street amenities (trees, awnings, benches, pedestrian-oriented lighting, etc.). Improve connections for nonmotorized travel, such as trails that link dead-end streets.

-Implement TDM; Use transportation demand management to reduce total vehicle traffic and encourage the use of efficient modes. This includes parking and road pricing, commute trip reduction programs, policies that favor high-occupancy vehicles, and other strategies.

-Preserve greenspace; Preserve open space, particularly areas with high ecological and recreational value. Channel development into areas that are already disturbed.

-Encourage a mix of housing types and price; Develop affordable housing near employment, commercial and transport centers. Develop second suites, apartments over shops, lofts, location-efficient mortgages and other innovations that help create more affordable housing.

-Utility Management; Use on-site storm water drainage systems. Encourage water conservation. (VTPI 2003)

4.3. Pros and Cons of Compact City Form

It is widely accepted that urban form influences travel patterns, the ability to maintain biodiversity and the quality of life. The land use planning system of each country is a key mechanism influencing urban form. Research conducted by the UK government has suggested that land use planning policies could reduce projected transport emissions by 16 percent over a 20 year period. The Green Paper on Urban Environment (1996) argues that the compact city form is likely to be the most energy efficient as well as having social and economic advantages. This concept advocates the development of new locations for urban development along existing rail infrastructure, and especially around notes of public transport and between already existing urban agglomerations. An important essential goal is the reduction of car mobility and increase the accessibility. The introduction of the concept of polynuclear orientation is related to compact city policy (WEB_4 2005).

Higher density urban form promotes social equity which is promotes benefits for the life chances of low income groups. Overall, the evidence suggests that for medium-sized English cities, higher urban densities may be positive for some aspect of social equity and negative for others. More specifically likely benefits include improved public transport, reduced social segregation and better access to facilities, while the main problem are likely to be reduced living space and a lack of affordable housing. (Burton 2000)

Although there are many critics on compact development pattern of cities, in many Western countries the concept of the "compact city" has been adopted as a guiding principle for urban sustainable development. It is commonly held that the compact city is the best policy goal to prevent or reduce the negative effects of urbanization on the environment (Walls 2000). There are many perceived benefits of the compact city over urban sprawl, which include: less car dependency consequently lower emissions, reduced energy consumption, better public transport services, increased overall accessibility, the re-use infrastructure and previously developed land, a renewal of existing urban areas and urban vitality, a higher quality of life, the preservation of green space, and the creation of a environment for enhanced business and trading activities.

Compact city form reduces distances between common activities (home, work, schools, services) and supports alternative modes (walking, cycling and transit), while sprawl disperses destinations and is automobile dependent. Sprawl results in longer but faster automobile trips, while compact form results in shorter, slower trips. The compact city has the potential to reduce rush hour traffic and commuting time, to encourage people to walk short distances, and to establish a safe and comfortable environment. A compact residential area describes concentrated and unified buildings in close proximity to each other and horizontally and vertically integrated land use pattern. Integrated land use is the mixture of different types of uses that have common interest and interrelated needs. Integrated land use combines uses that have no negative mutual impact on segregated land use. As such, integrated land use is the best applied to a compact city. (Golany and Ojima 1996)

The advantages of high density or compact cities for environmental sustainability have been increasingly discussed in the academic literature. The positive returns include more efficient use of motor vehicles and therefore a reduction in fossil fuel consumption, less congestion (when planned correctly), and more efficient infrastructure allocation among others.

As a structure of the city, compact strategies include a comprehensive plan that gives clear priority to compactness, large block or open space come close to urban neighborhoods, strong emphasis on infill development and intensification and more efficient use of abandoned or underutilized land within the urban core and high level of mixing and integration of functions. Transit oriented transportation system that prevent usage of the automobile and restricted travel times for commuters (Marcotullio 2001).

High density urban development also implies lower energy use for the building maintenance, especially because apartments are more compact and less dispersed than single family homes. High density dwellings are also usually smaller than dwellings in low density residential areas, and this, together with the reduced needs for infrastructure in dense towns, also implies that the requirement for construction material is usually lower. A compact city form is essential in achieving social and economic advantages. The compact is also claimed to allow energy-saving opportunities for new technologies, such as combined heat and power systems. Furthermore higher density performance are argued to be socially sustainable because local facilities and services can be maintained, due to high population densities and therefore accessibility to goods and services is more equitable distributed. Quality of life is argued to be good, because high density urban living is prerequisite for vitality, cultural activities and social interaction. Some have also claimed that economic benefits are associated with compactness because the high densities associated with the compact city can provide the concentrations of people to support local businesses and services (Williams 1999). But critics and economic advantages of technical infrastructure elements investment costs will be discussed next section of this chapter in terms in detail.

In suburban areas local identity and safety is largely negative. Intensification has often led to a decrease in the number of home-owning families and it is replaced by small households or single person households. Higher densities mean more neighbors. In terms of improving sense of safety this appears in successful town centers, where a higher densities and redevelopment have led to a greater sense of safety due to security cameras, increased policing and the concentration of entertainment facilities in the town center.

Critics generally concentrate on; lack of greenspace, increased congestion, house affordability, social justice, reduced quality of environment increased air and noise pollution and increased service costs. According to Brehenry at first sight compact city solution seems extremely sensible. It apparently meets the two primary environmentally objectives of reducing emission and protecting open countryside. However, when the two examined, the compact city solution begins to lose some of its cons. In terms of feasibility, major doubts have been raised here about the economic, technical and political prospects of delivering compaction. The economic doubt has been largely ignored in the debate (Brehenry 1997). Whitford claims locally such a compact city may have a poorer environment ecologically because it will tend to have a lower vegetation cover (Whitford 2001).

Overall, benefits or advantages of compact city considerably outweigh its disadvantages. All negative side effect of intense urban development pattern can be improved by Smart Growth strategies and policies implement although individual Smart Growth strategies have modest impacts, typically reducing per capita vehicle travel and land consumption by just a few percentage, their impacts are cumulative and synergetic. For example, increasing density, improving walkability and encouraging alternative commute modes may each only reduce per-capita vehicle travel by 2-4%, but if implemented together their total impacts are much larger. (VTI 2004)

All advantages and disadvantages of compact development pattern of cities summarized below;

Table 4.4. Pros and Cons of Compact City Form

PROS	CONS
Physical	
Provides proximity of land use for daily needs	Can be congested, resulting in a loss of some privacy
Significantly reduces transportation networks	High density building structure
Shortens utility length	Short of car park area
Increases use of pedestrian networks	Loss of urban open space
Provides proximity to nature	Lack of affordable housing
Provides proximity to public transport	Increased noise pollution
Reduced car dependency	
Increased overall accessibility	
Introducing new technology (combined heat and power system)	
Economic	
Conserves land for agriculture and other uses	Escalates land prices due to increased building density
Reduces energy consumption on transportation	
Reducing fuel use in buildings	
Provides efficient land use	
Shortens commuting time	
Saves time in design, construction, and maintenance	
Improved economic attractiveness for CBD	
Maintained local facilities and services	
More efficient utility and infrastructure provision	
Social	
Increases social propinquity and interaction	Requires adaptability and takes time
Increases interaction among age groups	
Improves urban self-image	
Increases use of public institutions	
Encourages pedestrian movement	
Improved sense of safety	
Social equity for low income	
Shorten arrival time in case of emergency	
Increased vitality for the usage of public spaces	
Health and Well-being	
Reduces air pollution	Potentially increases noise generated from public spaces
Protects against stressful climates	More stored carbon
Environmental	
Decreases land consumption	Innovative design is necessary and can be costly
Creates pleasing urban environment	Scarce green space
Less car dependency thus lower emission	Less run off
Conservation of the countryside	Ventilation and lighting problem for housing
	Chemical risk for households

4.4. Relationship between Urban Compactness and Service Cost

Smart Growth refers to development principles and planning practices that create more efficient land use and transport patterns. It includes numerous strategies that result in more accessible land use patterns and multi-modal transport systems. As previous chapter it is mentioned that sustainable development should seek the most efficient way of consuming natural resources (land, air, and water) and energy. While doing this it should be minimized the production of waste. Many researches showed that urban compactness provide significant contributions to this issue. Land use patterns affect the cost of providing public infrastructure and services such as roads, water, sewage, garbage collection, energy, communication… etc. Various studies show that these costs tend to increase with sprawl and can be reduced with urban compactness (also called smart growth, new urbanism). Most activities and urban technical services that involve distribution are more efficient with compact land use patterns, because less travel and shorten distance for network structure is required to reach destinations. Many researches demonstrated that low density development patterns had higher cost of provision of linear infrastructure than higher density development. Supporting document (*The Cost of Sprawl*) of this claim in 1974 published by Real Estate Research Corporation indicated a significant resource savings figures about higher density development pattern. In this report 6 hypothetical new suburban communities , each accommodate approximately 40.000 person compared with each other with respect to capital cost, operating cost of community services, energy and air pollution. Higher density community required 44% less capital investment, 11% less operating cost of community services, 45% less energy and 45% less air pollution. It is also indicated that provision of such services street lighting, street maintenance and water pumping for high density community reduces the energy saving figures (Vojnovic 1997). Although Smart Growth can provide a variety of economic, social and environment benefits summarized below, it has been criticized by various interest groups and individual researchers. They claimed that increased density requires more traffic light and traffic control officers to achieve a given level of traffic safety or traffic flow. Also it may raise the social cost of inappropriately disposed waste and therefore may require more waste collection and disposal. Finally increased density also requires more police services to achieve a given level of protection from crime (Ladd 1992).

Economic Benefits

- Reduced development cost,
- Reduced public service costs,
- Reduced transportation costs,
- Economies of agglomeration,
- More efficient transportation,

Support industries that depend on high quality environments (tourism, farming, etc.)

Social Benefits

- Improved transport options and mobility, particularly for non-drivers
- Improved housing options,
- Community cohesion,
- Preserves unique cultural resources (historic sites, traditional neighborhoods)
- Increased physical exercise and health

Environmental Benefits

- Greenspace and habitat preservation,
- Reduced air pollution,
- Increased energy efficiency,
- Reduced water pollution,
- Reduced "heat island" effect (Litman 2004).

Critics tend to assume that consumers prefer large single-family homes in automobile-dependent communities, and that current transport and land use policies are overall efficient and fair. As a result, they criticize Smart Growth as being harmful to consumers and the economy. This ignores evidence that many people will choose other housing and transport options if given suitable options and incentives, and if current markets are distorted in ways that resulted in sprawl and automobile dependency. Many Smart Growth strategies are market reforms that correct existing market distortions, increasing consumer options, economic efficiency and equity. Critics support some Smart Growth strategies by recognizing that these strategies increase market efficiency by increased scale and agglomerated structure of the economy. Critics generally focus on; increased regulations and reduced freedom; reduced affordability; increased congestion; inefficient usage of transit; overlooks on public service cost saving. Additionally some critics have an ideological opposition, on the assumption that Smart Growth increases government intervention in a free market. Critics argue that since home size and vehicle ownership rates generally increase with income that is why sprawl is inevitable. There are many exceptions and counter-trends, such as many wealthy people's preference for more urban homes and alternatives to driving. One of the Smart Growth benefits is its ability to reduced public infrastructure and service delivery costs. Many studies conclude that this type of development provide magnificent public cost savings identified various factors that affect these costs including density and distance from the existing urban center. Additionally public transport becomes more cost effective at higher densities because it enables public services, such as roads to be provided more efficiently and economically than at lower densities. High densities therefore generally result in a reduction of service costs. Another important point related urban density is that higher density development share land gaining and internal service cost with a large number of households. On the other hand higher residential development requires more expensive services as bigger diameter water and sewer pipes are required to accommodate greater loads. However, as additional demand placed on the system as a whole, total infrastructure costs increase as density increases. Therefore demand management systems on infrastructure in order to achieve sustainable development are more powerful than supply management systems.

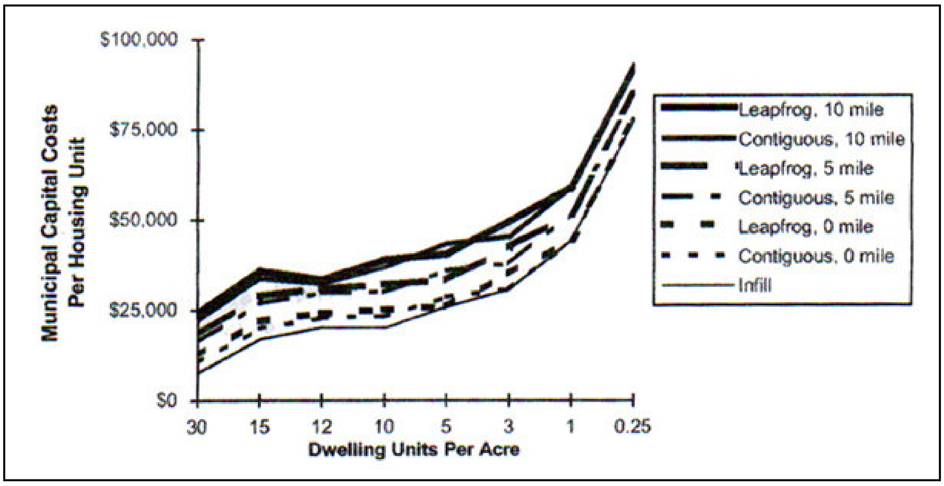


Figure 4.2. Residential Service Cost
(Source:Litman 2004, p.52)

Capital cost increase for lower density, non-contiguous development. Compared with sprawl, higher density, clustered, infill development can provide annual savings. According to Burchell and Mukherji (2003) report sprawl increases local road lane-miles

10%; annual public service costs about 10%.Figure 4.3. indicate that how school, road and utility costs per residential unit vary depending on development density. Rural sprawl costs are about 60% more than denser urban development.

Costs	Higher Density	Medium Density	Rural Cluster	Rural Sprawl
Units/Acre	4.5	2.67	1	0.2
Schools	$3,204	$3,252	$4,478	$4,526
Roads	$36	$53	$77	$154
Utilities	$336	$364	$497	$992
Totals	*$3,576*	*$3,669*	*$5,052*	*$5,672*
Incremental Cost	*NA*	*3%*	*41%*	*59%*

Per household annual municipal service costs increase with sprawl, based on a prototypical community of 1,000 units housing 3,260 people, 1,200 students. Compared with Higher Density, Rural Cluster increases costs 41%, and Rural Sprawl 59%.

Figure 4.3. Annualized Municipal Cost for Different Densities

(Source: Litman 2004, p.55)

In figure 4.4. it is summarized that public costs (utilities, government services and transportation infrastructure) for three possible development pattern in the Toronto region, showing significant saving for the more clustered option. In addition to these costs, the "Nodal" and "Central" options provide additional savings by reducing per capita annual vehicle mileage and eventually increase costs such as traffic congestion and pollution.

	Central	Nodal	Spread
Residents per Ha	152	98	66
Capital Costs (Billion C $1995)	39,1	45,1	54,8
O&M Costs (Billion C $1995)	10,10	11,8	14,3
Total Costs	49,2	56,9	69,1
Percent Savings over "Spread" option	40%	16%	NA

Figure 4.4. Public Costs of Three Development Options

(Source: Litman 2004)

There are many ways to measure congestion roadways that is Level of Service (LOS) ratings, per-capita congestion delay and average commute travel time, some of which reflect a mobility paradigm and others an accessibility paradigm.(VTI 2004) Denser areas tend to have higher roadway Level of Service (LOS) ratings (more intense congestion on a particular roadway) but relatively low per-capita congestion delay because shorter trip distances and improved travel options reduce per-capita vehicle mileage, while sprawled areas tend to have less intense congestion but more per capita congestion delay because residents travel more km by automobile.

Figure 4.5. compares the public infrastructure costs of a low density “Sprawl” and high density “Smart Growth” scenarios in the Twin City region. Costs per household are increase two times under the sprawl development patterns. It is calculated that incremental cost per unit for sprawl development option is $565. But this figure does not include ongoing public service costs that increase with sprawl, such as utility maintenance, emergency response and school busing. (Litman 2004)

	Sprawl (2.1 units/acre)	**Smart Growth (5,5 units/acre**
Miles of local roads	3,396	1,201
Costs of local roads per unit	$7,420	$2,607
Other infrastructure costs per unit	$10,954	$5,206
Total	$18,374	$7,813

Figure 4.5. Twin City Development Patterns Compared
(Source: Litman, 2004)

The city of Lancaster, California development impact fees that reflect the infrastruture costs of a particular location. (New Rules 2002) These fees are calculated by a civil engineering firm based on local development costs. The fees for a typical house located near the city edge are $5,500, but increase to $10,800 if located a mile away, reflecting the additional costs of providing more dispersed infrastructure. (Litman 2004)

Smart Growth includes development of more carefully planned communities, with schools located close to residential neighborhoods, improved walkability, traffic calming and other strategies to control vehicle traffic and improved public transit bus services. It also includes efforts to redevelop existing urban communities and improve public services. Each of these features can help reduce school busing requirement and providing saving to school districts, families and municipal governments.

The relationship between density and public costs is complex. Actual costs depend on the specific location and types of services provided. There are also incremental costs associated with increased density, including increased congestion and friction between activities, special costs for infill development and higher design standards. It is concluded that;

- Costs are low in rural areas where households provide their own services,

- Costs increase in suburban areas where services are provided to dispersed development,

- Costs decline with clustering, and as densities increase from low to moderate,

- Costs are lowest for infill redevelopment in areas with adequate infrastructure capacity. Costs tend to increase at very high densities because of congestion and high land costs. (Ewing 1997)

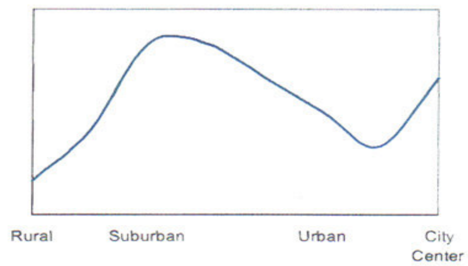


Figure 4.6. Land use Impacts on Public Infrastructure and Services Costs (Source: Litman 2004, p.57)

Public costs tend to be low in rural areas, where most residents provide their own water and sewage, and service standards are relatively low. They increase in suburban areas as more services are publicly supplied to dispersed areas, decline with increased clustering because of efficiencies, then increase at very high densities because of increased congestion. On the other hand the costs are reduce for increased density areas, because its reduction reflects resource cost saving that indicate reduction in total costs per unit. Other factors also affect public service costs. Single-use development results in inefficient use of infrastructure, increasing per capita costs; because the home and the workplace are entirely separated from each other create long auto trip. Generally on-going costs are overlooked. For example, many studies consider the incremental costs of constructing longer water and sewage lines, but not the incremental costs of maintaining and operating them. Throughout the thesis, all calculations for all infrastructure elements performed for initial construction costs for public sector.

Overall, the various studies indicate that Smart Growth (medium to high density, mixed-use development within existing urban areas) can provide direct saving in public development costs (roadways and utility lines) raging from $5,000 to $75,000 per unit, compared with the same quality of infrastructure provided to dispersed, automobile-dependent development. (Litman 2004)

Smart Growth can reduce development and public service costs by reducing the length of roads and utility lines, parking requirements, and travel costs to provide public services such as garbage, policing and school access. Smart Growth sometimes increases short-term costs but reduces long-term costs. For example, it may add costs for cleaning up brownfields and installing new infrastructure within urban areas, but provides transportation cost savings and reduces future public service and utility maintenance costs because activities are less dispersed. Smart Growth can impose some additional development costs, including special design requirements (such as additional pedestrian and structured parking facilities, and aesthetic features), higher costs for retrofitting infrastructure in high-density developed areas, and additional costs that may be needed to improve public services in urban neighborhoods in order to attract middle-class residents (Ewing 1997). As a result, actual cost savings will vary depending on the particular situation.

In order to define exact cost savings of urban technical infrastructure elements (Water, sewer, communication and electricity supply system) for public sector, two development area that are located within the development area of Aydın with different density are compared. Each residential area has equal units that are 54 units. One of them is (Torlak) showed in Figure 4.7 residential area that locate in high level income group area, mixed-use (commercial and residential), 13 storey apartment block (4 units on every flat) consists of 52 residential and 2 commercial units. 182 people live in 2775 m^2 and net density is 655 person/ha. The other development area is (Ayko) showed in figure 4.8 also residential area that is terraced duplex building. Except for housing type all features of housing area is identical with Torlak, but 54 units is residential. Additionally development density is 240 person/ha.

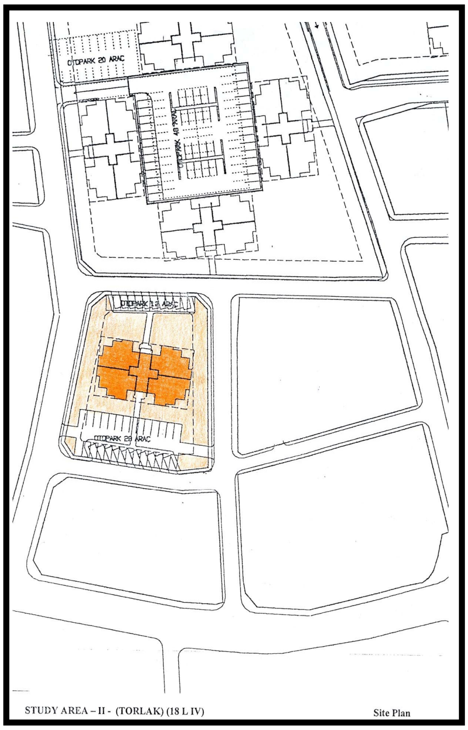


Figure 4.7 Site Plan of Study Area II (Torlak)

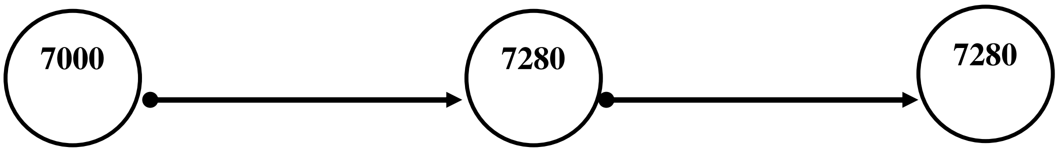
Figure 4.8 Site Plan of Study Area I (Ayko)

At first, total amount of construction for sewer pipeline system between each manhole point calculated for Study area I (Ayko).

STUDY AREA I- (AYKO) 20 J III

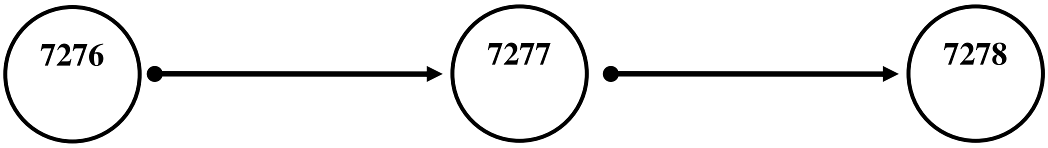
Calculation of Total Construction Cost

Sewer System Plan



RL – 93.13		RL – 93.03		RL – 93.23
PL – 91.22	L=40.50 m	PL – 91.05	L=35.50 m	PL – 91.00
h1= 1.91 m		h2= 1.98 m		h3= 2.23 m

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		43.00+38.00	81.00	81.00
1.416.003	Trench Excavation (m3)		(1.91+1.98)/2*40.50*0.90	70.895	
14.1714/1	Trench Refill (m3)		Total trench excavation	138.149	
	Pipe Volume (m3)		(40.50+35.50)*0.0549	-4.172	133.976
14.023/3	Retaining SupInstallation m2	2	(1.91+1.98)/2*40.50	157.545	
		2	(1.98+2.23)/2*35.50	149.455	307.000
N.F.A.1	Pipe Transportation		81.00*0.073	5.913	5.913

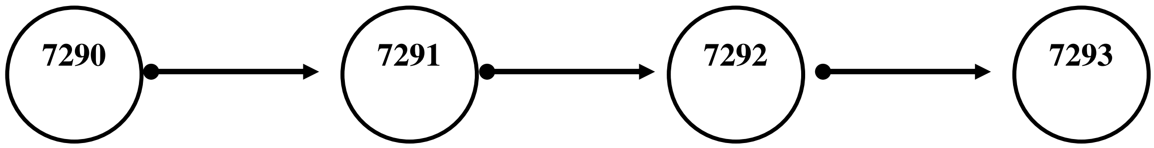


RL -97.41 RL – 95.14 RL – 93.41
PL – 95.17 PL – 93.17 PL – 91.33
h1= 2.24 L= 28.50 m h2= 1.97 m L= 31.50 m h3=
2.08 m

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		31.00+34.00	65.00	65.00
1.416.003	Trench Excavation (m3)		(2.24+1.97)/2*28.50*0.90	53.993	
			(1.97+2.08)/2*31.50*0.90	57.408	111.401
14.1714/1	Trench Refill (m3)		Total Trench Excavation	111.401	
	Pipe volume (m3)		(28.50+31.50)*0.0549	-3.294	108.107
14.023/3	Retaining Support Installation (m2)	2	(2.24+1.97)/2*28.80	119.985	
		2	(1.97+2.08)/2*31.50	127.575	247.560
N.F.A.1	Pipe Transportation		65.00*0.073	4.745	4.745

RL – 93.41 L= 35.50 m RL – 93.13
PL – 91.33 PL – 91.12
h1= 2.08 m h2= 2.01 m

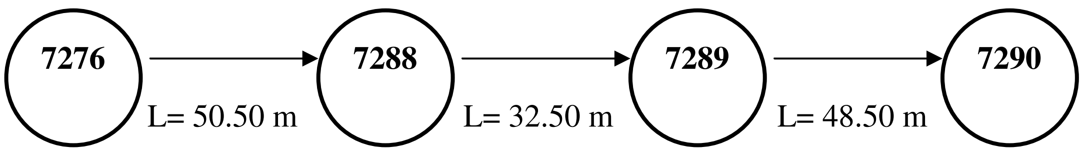
no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		38.00	38.00	38.00
1.416.003	Trench Excavation (m3)		(2.08+2.01)/2*35.50*0.90	65.337	65.337
14.1714/1	Trench Refill (m3)		Total trench excavation	65.337	
	Pipe volume (m3)		35.50*0.0549	-1.948	63.388
14.023/3	Retaining Support installation	2	(2.08+2.01)/2*35.50	145.195	145.195
N.F.A.1	Pipe Transportation		38.00*0.073	2.774	2.774



L=36.50 m L= 25.50 L= 28.50 m

RL – 96.81	RL – 95.51	RL – 94.48	RL – 93.23
PL – 95.24	PL – 93.73	PL – 92.25	PL – 91.00
h1= 1.57 m	h2 – 1.78 m	h3= 2.23 m	h4= 2.23 m

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		39.00+28.00+31.00	98.00	98.00
1.416.003	Trench Excavation (m3)		(1.57+1.78)/2*36.50*0.90	55.023	
			(1.78+2.23)/2*25.50*0.90	46.014	
			(2.23+2.23)/2*28.50*0.90	57.801	158.838
14.1714/1	Trench Refill (m3)		Total trench Excavation	158.838	
	Pipe volume		(36.50+25.50+28.50)*0.0549	-4.968	153.870
14.023/3	Retaining Support Installation (m2)	2	(1.57+1.78)/2*36.50	122.274	
		2	(1.78+2.23)/2*25.50	102.254	
		2	(2.23+2.23)/2*28.50	127.110	351.638
N.F.A.1	Pipe Transportation		98.00*0.073	7.154	7.154



RL – 97.41	RL – 96.98	RL – 96.99	RL – 96.81
PL – 95.17	PL – 95.48	PL – 95.45	PL – 95.24
h1= 2.24 m	h2= 1.50 m	h3= 1.54 m	h4= 1.57 m

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		53.00+35.00+51.00	139.00	139.00
1.416.003	Trench Excavation (m3)		(2.24+1.50)/2*50.50*0.90	84.991	
			(1.50+1.54)/2*32.50*0.90	44.460	
			(1.54+1.57)/2*48.50*0.90	67.875	197.326
14.1714/1	Trench Refill (m3)		Total Trench Excavation	197.326	
	Pipe volume		(50.50+32.50+48.50)*0.0549	-7.219	190.106
14.023/3	Retaining upport Installation(m2)	2	(2.24+1.50)/2*50.50	94.435	
		2	(1.50+1.54)/2*32.50	98.800	
		2	(1.54+1.57)/2*48.50	150.835	344.070
N.F.A.1	Pipe Transportation		139.00*0.073	10.147	10.147

Calculation of Total Construction Cost

Manhole Installation

Table 4.5.Construction Calculation for Each Task of Manhole Installation (Study area I)

no	Task	Calculation	Min.	Max.
14.160.040	(0-2)m Base Excavation (m3)	2,50*2,50*20,93	130,816	130,816
14.160.041	(2-3)m Base Excavation (m3)	2,50*2,50*2,00	12,500	12,500
14.1714/1	Trench Refill (m3)	Total amount of excavation	143,316	
	Conic Part	11*0.5	-5,500	
	Body	13,65*1,131	-15,438	
	Base	11*0,265	-2,915	
	Pipe Volume (200mm)	24*0,65*0,0549	-0,856	118,606
14.023/3	Retaining Support Installation	4*2,50*22,93	229,300	
	Trench Entrance	2*0.90*22,93	41,274	188,026
12.2188/1A	1 m.Body Ring Installation	13,65	13,650	13,650
12.189/1A	1 m.Conic Installation	11	11	11
N.F.A.4/A	Concrete Cover Transportation	11*0,129	1,419	1,419
N.F.A..5	Prefabric Manhole Transportation			
	Conic Part	11*0,389	4,279	
	Base	11*0,389	4,279	
	Body	13,65*0,828	11,302	19,860

Then, for each manhole point, total excavation amount calculated.

Calculation of Total Construction Cost

Manhole Installation

Table 4.6. Construction Calculation for Each Manhole (Study area I)

no	Manhole No	Connection	Road Level	Pipeline Level	Manhole Level	Excavation Height	Manhole Height	Excavation	
								0-2	2-3
1	7293	4	93,23	91,00	93,23	2,41	1,55	2,00	0,41
2	7292	2	94,48	92,25	94,48	2,41	1,55	2,00	0,41
3	7291	2	95,51	93,73	95,51	1,96	1,10	1,96	0,00
4	7290	2	96,81	95,24	96,81	1,75	0,89	1,75	0,00
5	7289	2	96,99	95,45	96,99	1,72	0,86	1,72	0,00
6	7288	2	96,98	95,48	96,98	1,50	0,82	1,50	0,00
7	7276	2	97,41	95,17	97,41	2,42	1,56	2,00	0,42
8	7277	2	95,14	93,17	95,14	2,15	1,29	2,00	0,15
9	7278	2	93,41	91,33	93,41	2,26	1,40	2,00	0,26
10	7000	2	93,13	91,12	93,13	2,19	1,33	2,00	0,19
11	7280	2	93,03	91,05	93,03	2,16	1,30	2,00	0,16
		24				**22,93**	**13,65**	**20,93**	**2,00**

After that, using calculated values for manhole point total cost calculated for manhole installation.

Calculation of Total Construction Cost

Manhole Installation

Table 4.7. Price Calculation for Each Task of Manhole Installation (Study area I)

No	Task	AD	Total Amount	Unit Price (YTL)	Total Cost (YTL)
14.160.040	(0-2) m Base Excavation (m3)		130,816	1.76	230.19
14.160.041	(2-3) m Base Excavation (m3)		12,500	1.82	22.84
14.1714/1	Trench Refill(m3)		118,606	1.86	220.43
14.023/3	İksa Installation (m2)		188,026	4.88	916.86
12.2188/1A	1 m Body Ring Installation		13,650	4.22	57.65
12.189/1A	1 m Conic Installation		11	1.61	17.73
N.F.A.4A	Manhole Cover Transportation		1,419	8.58	12.17
N.F.A.5	Prefabric Manhole Transportation		19,86	9.81	194.76
08/157 6/1	Conic Part	11		41.82	459.96
08 1577	Top Ring	11		11.39	125.31
08 1575/1	Body Ring	23		44.43	1021.80
08 1579/1-1	Base	11		142.154.233	1563.70
23 255 /İB3	Iron Grid (88kg)	968kg		1.30	1253.86
23 255/İB-1	Manhole Cover (104kg)	1144kg		1.47	1683.54
TOTAL					**7780.81**

(İller Bankası Unit Cost 2002)

At that point additional to manhole cost calculation, pipeline cost calculation performed.

Calculation of Total Construction Cost

Pipeline Installation

Table 4.8. Price Calculation for Each Task of Pipeline Installation (Study area I)

no	Task	Total Amount	Unit Price (YTL)	Total Cost (YTL)
12.218.332	200 Pipe Installation (m)	421,000	2.10	884.96
1.416.003	Trench Excavation (m3)	671,051	2.29	1533.79
14.1714/1	Trench Refill (m3)	649,447	1.86	1207.02
14.023/3	Retaining Support Installation (m2)	1171,412	4.88	5712.10
N.F.A.1	Concrete Pipe Transportation	30,733	9.81	3013.88
08.157.061	Pipe Cost	421,000	5.54	2334.30
TOTAL (Pipeline Installation Cost)				**14686.05**
TOTAL (Pipeline + Manhole Installation)				**22466.85**

(İller Bankası Unit Price 2002)

All calculations have been achieved for water supply, electricity and communication system network.

Calculation of Total Construction Cost

Water Supply System Plan

Table 4.9.Construction Calculation for Each Task of Water Supply System (Study area I)

no	Task	Ad	Calculations	Min.	Max.
3.609.005	100 PVC Pipeline (m)		108+111+79+80+41+7.378	426.378	426.378
14.160.03	Trench Excavation (m3)		1.10*0.60*108	71.28	71.28
			1.10*0.60*111	73.26	73.26
			1.10*0.60*79	52.14	52.14
			1.10*0.60*80	52.80	52.80
			1.10*0.60*41	27.06	27.06
					276.540
14.1714/1	Trench Refill (m3)		Total trench excavation	276.540	
			426.378*(3.14*0.16*0.1614)	-34.573	241.976
36.13005	100 mm Vault Installation	2			
36.11101	AÇB Special Part Installation	17	17*14.500kg	246.500	246.500

Calculation of Total Construction Cost

Water Supply System Plan

Table 4.10.Price Calculation for Each Task of Water Supply System (Study area I)

no	Task	Total Amount	Unit Price (YTL)	Total Cost (YTL)
36.06009	100 PVC Pipeline (m)	426.328	0.26	111.51
14.160030	Trench Installation (m3)	276.540	1.27	352.18
14.1714/1	Trench Refill (m3)	241.976	0.870	210.73
	100 Fire Hydrant Cost	1	250.00	250.00
	GMMA T-Part Cost	17	16.00	272.00
	100 Vault Cost	2	100.00	200.00
	100 Vault Installation	2	1.43	2.87
	AÇB Special Part Installation	246.500kg	49.297	12.15
8.157.061	Pipe Cost	426.328	5.75	2451.39
TOTAL				**3862.84**

(İller Bankası Unit Cost 2002)

Total Construction Cost Calculation

Communication Network Plan

Table 4.11.Price Calculation for Each Task of Communication Network (Study area I)

KOD	Task	Total Amount	Unit Price 04.09.2001	Total Cost (04.09.2001)
OO1	KPDF-APA 20-0.4	220	0.765	168.35
OO2	KPDF-APA 30-0.4	20	0.946	18.93
OO4	KPDF-APA 100-0.4	100	2.16	215.91
304	10 External Distributor Box	10	5.17	51.67
282	BEKT A	5	7.23	36.17
283	BEKT B	3	11.54	34.62
246	Small Connector (0.4, 0.5)	280	0.22	6.33
TOTAL				**531.98**

Total Construction Cost Calculation

Communication Network Plan

Table4.12. Installation Calculation for Each Task of Communication Supply System (Study area I)

KOD	POZ	Task	Total Amount	Unit Cost 04.09.2001	Total Cost (04.09.2001)
119	5.2	Cable Installation (m)	340	3.61	1226.80
136	11.1	Connector Installation	140	0.731	102.47
138	12.1	Cover with BEKT	8	17.60	140.80
116	4.1	Fider Installation on Wall	1	16.12	16.12
124	6.1	10 Box Installation	10	13.94	139.41
TOTAL (Installation Cost)					**1625.60**
TOTAL (Installation + Unit Cost)					**2157.58**

Calculation of Total Construction Cost

Electricity Supply System Plan

Table 4.13.Price Calculation for Each Task of Electricity Supply System (Study area I)

Task	Unit Type	Total Amount	Unit Cost (TL)	Total Cost (TL)
Fixtures	3 / 9.30	8	74.40	595.20
	6 / 9.30	2	109.88	219.76
	8 / 9.30	4	137.07	536.28
	10 / 9.30	1	150.60	150.60
Conductors	Aster	0.942 km- 177 kg	3.94	697.56
	Pansy	0.314km- 37 kg	3.94	145.82
	Rose	0.508 km- 30 kg	3.94	118.23
Insulators	N-95	36	0.956	34.42
	N-80	30	0.753	22.59
Iron Parts	B-95	36	0.680	24.48
	B-80	30	0.578	17.34
Travers	t-60	22	1.81	39.84
	n-60	18	2.93	52.70
	N-90	3	3.60	10.79
Total (Equipment Cost)				**2665.61**
(Tedaş Unit Cost 2002)				

Calculation of Total Construction Cost

Electricity Supply System Plan

Table4.14.Construction Calculation for Each Task of Electricity Supply System (Study area I)

Task	Unit Type	Total Amount	Unit Cost (YTL)	Total Cost (YTL)
Fixtures	3 / 9.30	745*8=5960kg		
	6 / 9.30	1125*2=2250kg		
	8 / 9.30	1510*4=6040kg		
	10 / 9.30	1540*1=1540kg		
		15790kg	0.15	2380.66
Conductors	Aster	0.942 km- 177 kg	0.89	157.23
	Pansy	0.314 km- 37 kg	1.16	43.11
	Rose	0.508 km- 30 kg	2.05	61.40
Insulators	N-95	36	0.57	20.38
	N-80	30	0.53	16.00
Iron Parts	B-95	36	-	-
	B-80	30	-	-
Travers	t-60	22*7=154kg		
	n-60	18*11=198kg		
	N-90	3*16=48kg		
		400kg	0.11	45.34
Total Installation Cost				**2724.12**
Total (Installation + Equipment Cost				**5389.73**
(TEDAŞ Unit Price 2002)				

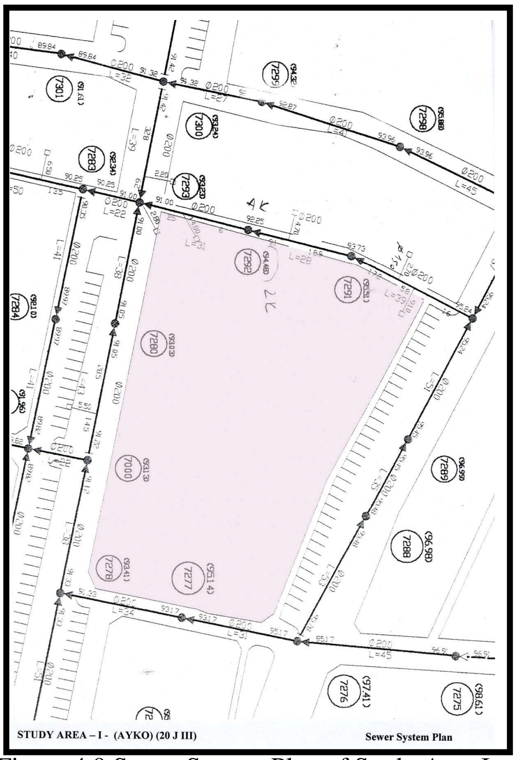


Figure 4.9 Sewer System Plan of Study Area I

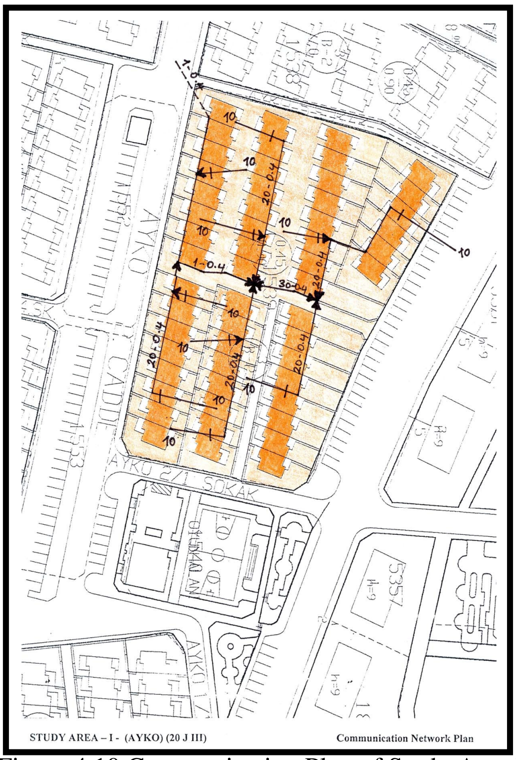


Figure 4.10.Communication Plan of Study Area I

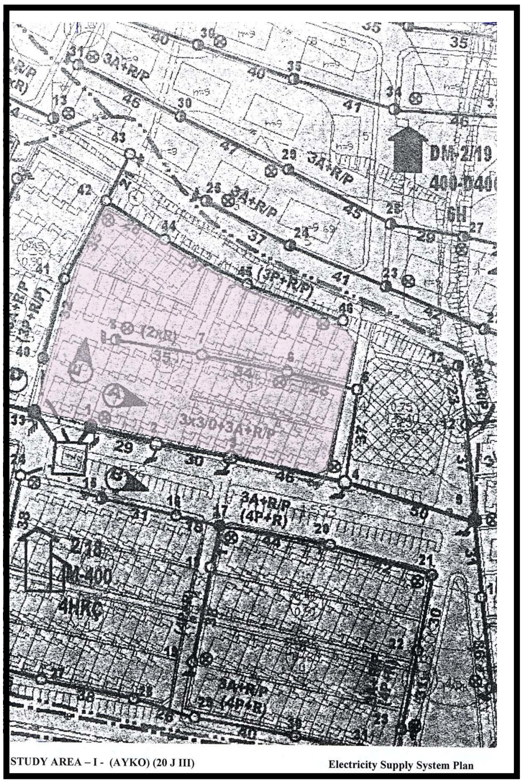


Figure 4.11 Water Supply System Plan of Study Area I

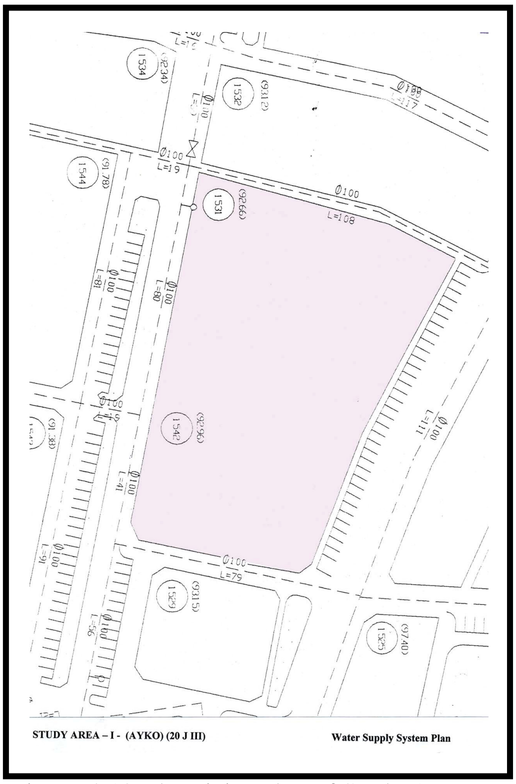
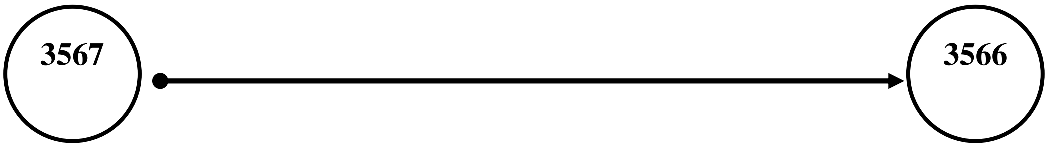


Figure 4.12 Electricity Plan of Study Area I

Previous installation calculations for sewer, water, electricity and communication supply system network performed again for Study area II (Torlak)

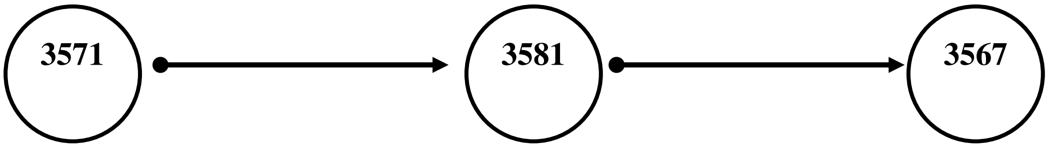
Calculation of Total Construction Cost

Sewer System Plan



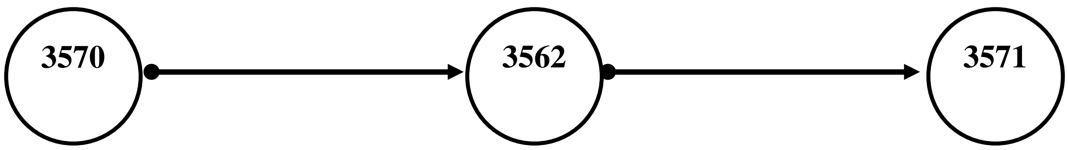
RL – 51.80 L=55.50 m RL - 52.46
PL – 49.88 PL - 50.56
h1 = 1.92 m h2 =1.90 m

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		58.00	58.00	58.00
1.416.003	Trench Excavation (m3)		(1.92+1.90)/2*55.50*0.90	95.404	95.404
14.1714/1	Trench Refill (m3)		Total Trench Excavation	95.404	
	Pipe Volume (m3)		55.50*0.0549	-3.046	92.357
14.023/3	Retaining Support Installation (m2)	R		212.010	212.010
N.F.A.1	Pipe Installation		58.00*0.073	4.234	4.234



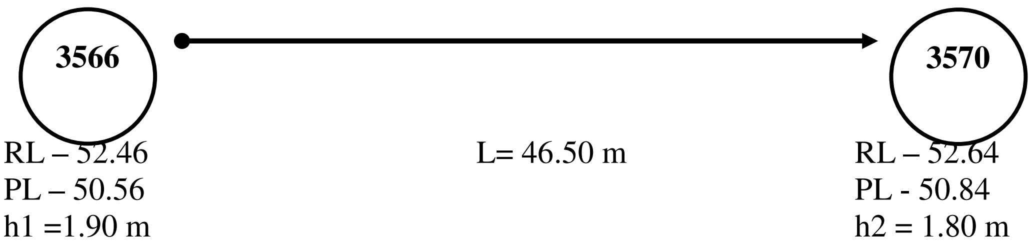
RL – 51.73 RL - 51.85 RL - 51.80
PL – 49.91 L=17.50 m PL - 50.05 L= 48.50 m PL - 49.88
h1= 1.82 h2=1.80 h3=1.92

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		20.00+51.00	71.00	71.00
1.416.003	Trench Excavation (m3)		(1.82+1.80)/2*17.50*0.90	28.507	
14.1714/1	Trench Refill (m3)		Total Trench Excavation	109.696	
	Pipe Volume (m3)		(17.50+48.50)*0.0549	-3.623	106.073
14.023/3	Retaining Support Installation (m2)	2	(1.82+1.80)/2*17.50	36.350	
		2	(1.80+1.92)/2*48.50	180.420	243.770
N.F.A.1	Pipe Installation		71.00*0.073	5.183	5.183



RL – 52.64 RL – 52.50 RL- 51.73
PL- 50.74 L= 13.50 PL – 50.64 L= 39.50 PL- 49.91
h1= 1.90 m h2= 1.86 m h3= 1.82 m

no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)		16.00+42.00	58.00	58.00
1.416.003	Trench Excavation (m3)		(1.90+1.86)/2*13.50*0.90	22.842	
			(1.86+1.82)/2*39.5*0.90	65.412	88.254
14.1714/1	Trench Refill (m3)		Total Trench Excavation	88.254	
	Pipe Volume (m3)		(13.50+39.50)*0.0549	-2.909	85.344
14.023/3	Retaining Support Installation (m2)	2	(1.90+1.86)/2*13.50	50.760	
		2	(1.86+1.82)/2*39.50	145.360	196.120
N.F.A.1	Pipe Installation		58.00*0.073	4.234	4.234



no	Task	Ad	Calculation	Min.	Max.
12.218.332	200 mm Pipeline (m)			46.50	46.50
1.416.003	Trench Excavation (m3)		(1.90+1.80)/2*46.50*0.90	77.422	77.422
14.1714/1	Trench Refill (m3)		Total Trench Excavation	77.422	
	Pipe Volume (m3)		46.50*0.0549	-2.552	74.869
14.023/3	Retaining Support Installation (m2)	2	(1.90+1.80)/2*46.50	172.050	172.050
N.F.A.1	Pipe Installation		49.00*0.073	3.577	3.577

Calculation of Total Construction Cost

Manhole Installation

Table 4.15. Construction Calculation for Each Task of Manhole Installation (Study area II)

no	Task	Calculation	Min.	Max.
14.160.040	(0-2)m Base Excavation	2,50*2,50*11,98	74,875	74,875
14.160.041	(2-3)m Base Excavation	2,50*2,50*0,34	2,125	2,125
14.1714/1	Trench Refill (m3)	Total Amount of Excavation	77,000	
	Conic Part	6*0.5	3,000	
	Body	7,16*1,131	8,098	
	Base	6*0,265	1,590	
	Pipe Volume (200mm)	12*0,65*0,0549	0,428	63,884
14.023/3	Retaining Support Installation (m2)	4*2,50*12,32	123,200	
	Trench Entrance	2*0.90*12,32	22,176	101,024
12.2188/1A	1 m.Body Ring Installation	7,16	7,160	7,160
12.189/1A	1 m.Conic Installation	6	6	6
N.F.A.4/A	Concrete Cover Transportation	6*0,129	0,774	0,774
N.F.A..5	Prefabric Manhole Transportation			
	Conic Part	6*0,389	2,334	
	Base	6*0,389	2,224	
	Body	7,16*0,828	5,928	10,596

Calculation of Total Construction Cost

Manhole Installation

Table 4.16. Construction Calculation for Each Manhole (Study area II)

no	Manhole No	Connection	Road Level	Pipeline Level	Manhole Level	Excavation Height	Manhole Height	Excavation	
								0-2	2-3
1	3566	2	52.46	50.56	52.46	2,08	1,22	2,00	0,08
2	3570	2	52,64	50,84	52,64	1,98	1,12	1,98	0,00
3	3562	2	52,50	50,64	52,50	2,04	1,18	2,00	0,04
4	3571	2	51,73	49,91	51,73	2,00	1,14	2,00	0,00
5	3581	2	51.85	49,91	51,85	2,12	1,26	2,00	0,12
6	3567	2	51,80	49,88	51,80	2,10	1,24	2,00	0,10
Total		**12**				**12,32**	**7,16**	**11,98**	**0,34**

Calculation of Total Construction Cost

Manhole Installation

Table 4.17. Price Calculation for Each Manhole (Study area II)

no	Task	AD	Total Amount	Unit Price (YTL)	Total Cost (YTL)
14.160.040	(0-2) m Base Excavation (m3)		74,875	1.76	131.75
14.160.041	(2-3) m Base Excavation (m3)		2,125	1.83	3.88
14.1714/1	Trench Refill (m3)		63,884	1.86	118.73
14.023/3	Retaining Support Installation (m2)		101,024	4.88	492.62
12.2188/1A	1 m Body Ring Installation		7,160	4.22	30.24
12.189/1A	1 m Conic Installation		6,000	1.61	9.67
N.F.A.4A	Manhole Cover Transportation		0,774	8.58	6.64
N.F.A.5	Prefabric Manhole Transportation		10,586	9.81	103.91
08 1576/1	Conic Part	5		41.82	209.07
08 1577	Top Ring	5		11.40	56.96
08 1575/1	Body Ring	12		44.43	533.12
08 1579/1-1	Base	5		142.15	710.77
23 255/İB-3	Iron Grid (88kg)	440kg		1.30	569.94
23 255/İB-1	Manhole Cover (104 kg)	520kg		1.47	765.24
TOTAL					**3742.55**

(İller Bankası Unit Price 2002)

Calculation of Total Construction Cost

Pipeline Installation

Table 4.18. Price Calculation for Each Task of Pipeline Installation (Study area II)

no	Task	Total Amount	Unit Price (YTL)	Total Cost (YTL)
12.218.332	200 mm Pipe Installation (m)	236,000	2,10	496.08
1.416.003	Trench Excavation (m3)	370,776	2.28	847.46
14.1714/1	Trench Refill (m3)	358,643	1.86	666.55
14.023/3	Retaining Support Installation (m2)	823,950	4.88	4017.79
N.F.A.1	Concrete Pipe Transportation	17,228	9.81	168.95
8.157.061	Pipe Cost	236,000	5.54	1308.54
TOTAL (Pipeline Installation Cost)				**7505.37**
TOTAL (Pipeline + Manhole Installation)				**11247.92**

(İller Bankası Unit Price 2002)

Calculation of Total Construction Cost

Water Supply System Plan

Table 4.19. Construction Calculation for Each Task of Water Supply (Study area II)

no	Task	Ad	Calculation	Min.	Max.
3.606.009	100 PVC Pipeline (m)		51+59+61+58+4.774	233.774	233.774
14.160.030	Trench Excavation (m3)		1.10*0.60*51	33.66	33.66
			1.10*0.60*59	38.94	38.94
			1.10*0.60*61	40.26	40.26
			1.10*0.60*58	38.28	38.28
					151.120
14.1714/1	Trench Refill (m3)		Total Trench Excavation	151.120	
			151.120*(3.14*0.16*0.1614)	-13.268	
					137.851
36.13005	100 mm Vault Installation	-			
36.11101	AÇB Special Part Installation	11	11*14.500	159.500	159.500

Calculation of Total Construction Cost

Water Supply System Plan

Table 4.20.Price Calculation for Each Task of Water Supply System (Study area II)

no	Task	Total Amount	Unit Price (YTL)	Total Cost (YTL)
36.06009	100 mm PVC Pipeline (m)	233.774	0.261	61.15
14.160030	Trench Excavation (m3)	151.120	1.27	192.46
14.1714/1	Trench Refill (m3)	137.851	0.870	120.05
	100 Fire Hydrant Cost	1	250.00	250.00
	GMMA T Part Cost	11	16.00	176.00
	AÇB Special Part Installation	159.500kg	0.49	7.86
8.157.061	Pipe Cost	233.774	5.54	1344.20
TOTAL				**2151.72**

(İller Bankası Unit Price 2002)

Total Construction Cost Calculation

Communication Network Plan

Table 4.21 Equipment Cost Calculation for Each Task of Communication (Study area II)

KOD	Task	Total Amount	Unit Price 04.09.2001	Total Cost (04.09.2001)
030	KPDF-AP 100-0.4	70	1.87	130.97
308	100 External Distributor Box	1	17.14	17.14
TOTAL				**148.10**

Total Construction Cost Calculation

Communication Network Plan

Table 4.22. Installation Cost Calculation Table for Each Task (Study area II)

KOD	POZ	Task	Total Amount	Unit Cost 04.09.2001	Total Cost (04.09.2001)
120	5.3	Cable Installation (m)	70	3.65	255.81
116	4.1	Fider Installation on Wall	1	16.12	16.12
128	6.5	100 Box Installation	1	34.85	34.85
TOTAL (Installation Cost)					**306.78**
TOPLAM (Installation + Equipment Cost)					**454.89**

Calculation of Total Construction Cost

Electricity Supply System Plan

Table 4.23. Equipment Cost Calculation for Each Task of Electricity Supply System (Study area II)

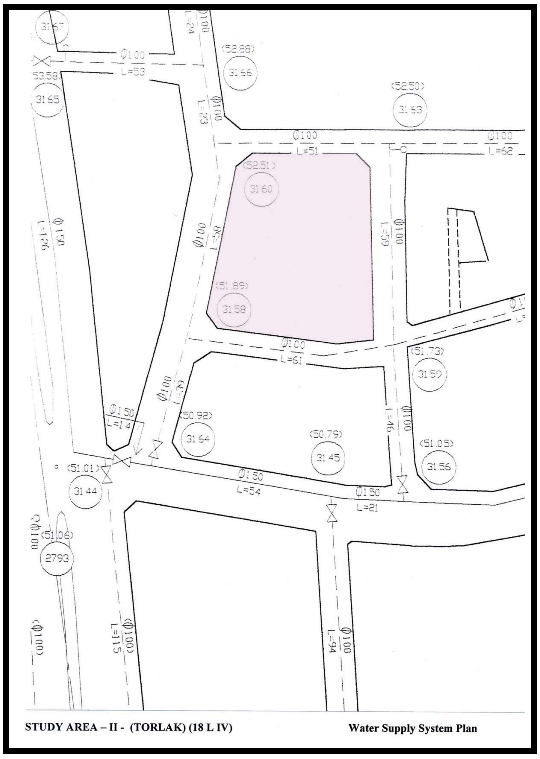
Task	Unit Type	Total Amount	Unit Cost (YTL)	Total Cost (YTL)
Fixtures	3 / 9.30	1	74.40	223.20
	6 / 9.30	1	109.88	329.64
	8 / 9.30	2	137.07	268.14
	10 / 9.30	1	150.60	451.80
Conductors	Aster	0.6 km- 113 kg	3.94	445.33
	Pansy	0.2 km- 24 kg	3.94	94.58
	Rose	0.2 km- 12 kg	3.94	47.29
Insulators	N-95	15	0.956	14.34
	N-80	10	0.753	7.53
Iron Parts	B-95	15	0.680	10.20
	B-80	10	0.578	5.78
Travers	t-60	12	1.81	21.73
	n-60	3	2.93	8.78
Total (Equipment Cost)				**1928.35**
(TEDAŞ Unit Price 2002)				

Calculation of Total Construction Cost

Electricity Supply System Plan

Table 4.24. Installation Cost Calculation for Each Task of Electricity Supply System (Study area II)

Task	Unit Type	Total Amount	Unit Cost (YTL)	Total Cost (YTL)
Fixtures	3 / 9.30	745 kg		
	6 / 9.30	1125 kg		
	8 / 9.30	1510*2=3020 kg		
	10 / 9.30	1540 kg		
		6430 kg	0.150	969.45
Conductors	Aster	0.6 km- 113 kg	0.888	100.38
	Pansy	0.2 km- 24 kg	1.16	27.96
	Rose	0.2 km- 12 kg	2.05	24.56
Insulators	N-95	15	0.566	8.50
	N-80	10	0.533	5.34
Iron Parts	B-95	15	-	-
	B-80	10	-	-
Travers	t-60	7 kg*12=84kg		
	n-60	11 kg*3=33kg		
		117 kg	0.113	13.34
Total Installation Cost				**1149.51**
Total (Installation + Equipment) Cost				**3077.87**
(Tedaş Unit Price 2002)				



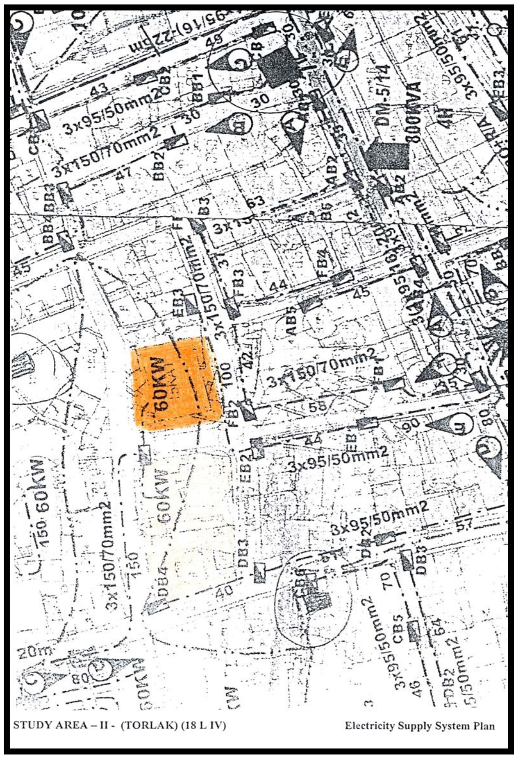
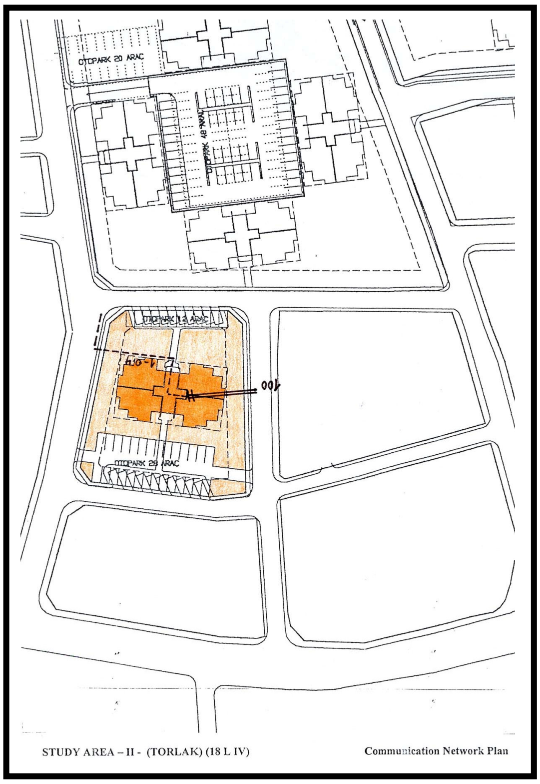


Figure 4.13. Water Supply System Plan of StudyAreaII Figure 4.14 Electricity System Plan of Study Area II



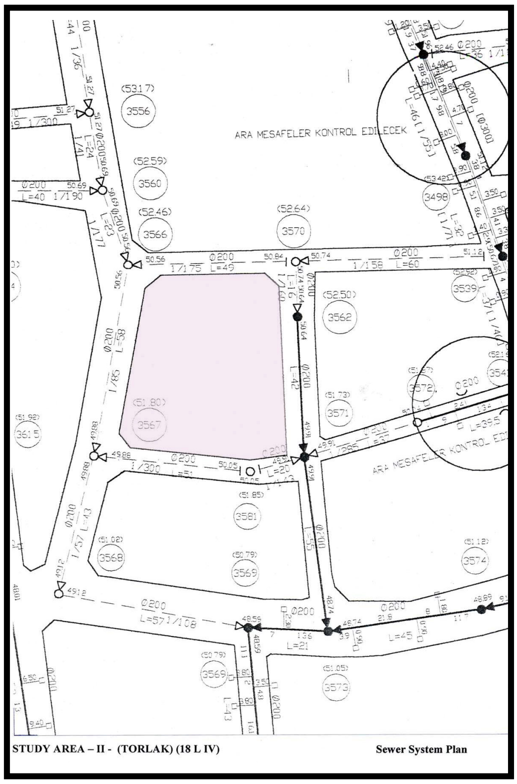


Figure 4.15. Communication Plan of Study Area II

Figure 4.16. Sewer System Plan of Study Area II

Table 4.25. Comparasion of Total Infrastructure Constructure Costs of Study area I and II OF Aydın

AYDIN Study Area I- II Total Infrastructure Public Investment Cost (YTL)						
	Study Area I- AYKO	**% Distribution**	**Study Area II- TORLAK**	**% Distribution**	**Total Cost (AYKO+TORLAK)**	**Decrease Rate Based to Torlak %**
Sewer System Plan Cost	22466,85	66,32	11247,92	66,43	33714,77	99,75
Water Supply System Plan Cost	3862,84	11,40	2151,72	12,71	6014,56	79,54
Electricity Supply System Plan Cost	5389,73	15,91	3077,87	18,18	8467,6	75,13
Communication Network Plan Cost	2157,58	6,37	454,89	2,69	2612,47	375,11
TOTAL COST	**33877**		**16932,4**			
2002 Unit Prize used for all Calculations						

Compared to study area I (Ayko), Study area II (Torlak) reduce the total infrastructure investment costs 100% in total. Particularly, decrease in sewer, water, electricity and communication supply system is 99.75, 79.54, 75.13 and 375.11 respectively. Sewer system investment cost has a great part of the total construction cost for both area that is approximately 66% of total. Surprisingly cost of communication network installation cost reduced 2.69% of Torlak, while it is 6.37% for Ayko. Another interesting point is; although density increase 240 p/ha to 655 p/ha, rate of water and electricity construction cost are similar in total rates.

4.5. Means and Tools to Achieve Compact City Form

Air and water pollution, global warming and the greenhouse effect, reduction of raw materials and natural resources, the loss of green/recreation areas affected bio-diversity and create user-unfriendly living environments. Apart from these facts, there is also a concern regarding population growth. Today there is an obvious necessity for new building methods or new development pattern which would reuse and recycle and reduce land consumption and building materials and components. These are important aspects of sustainable development.

To get rid of the negative side effects of the current development process and critics on compact city, multi-layered land use planning and underground usage (geo-space usage) seems to be probable resolution for future development. Current implementation that derived from lack of development space (Japan and Netherlands), severe climatic conditions (Montreal) and environmental considerations (Australia) save great amount of surface space and lead an increase in open space in built environment. Traditional planning practices generally give a direction to the cities development by means of using above ground regulations. But many land use decisions called "windowless usage" see table 28 do not need daylight and therefore can be located underground.

At the moment there are two main groups of processes taking place for urban form development. One group focuses on finding new expansion areas and the other group focus on city renewal in other words renewal of existing urban structure especially improving the quality of existing city centers (Durmusevic 1999). Cities will require more efficient use of space in the future. In order to preserve the city as a cultural, social and economic centre there is a need for more compact solutions. Locating some functions that summarized in table 28 such as traffic, shopping, catering facilities, cinemas, museums and theatres) underground will create more space aboveground for recreation and social activities in the neighborhood of residential areas, and will also create possibilities for the development of new residential areas. In such a way, the city's vertical line can be utilized more efficiently by integrating subsurface spaces with the aboveground city's network.

Locating particular activities and services underground and its advantages can be categorized;

- land space and locational advantages;
- physical and isolation advantages;
- topographic freedom advantages (Sterling 1997).

Table 4.26. Urban Windowless Environments Implementable in Geo-Space
(Source: Golany, G. S., 1996)

AGRICULTURE AND FOOD	• Crafts and handiwork	• Theaters
	• Meditation centers	• Video rental shops
• Bakeries	• Music stores	• Wrestling arenas
• Catering services	• Sculpture	
• Meat-packing plants	• Sewing and fabric shops	**FINANCIAL CENTERS**
• Meat retail and wholesale shops	• Writing supply stores	• Banking services
		• Banks
• Mushroom growing	**EDUCATIONAL FACILITIES**	• Brokers, financial services
• Raising chickens	• Art schools	• Clearinghouses
• Shops, department stores of all types	• Bookshops	• Insurance companies
	• Classrooms: schools,	• Real estate offices
• Slaughterhouses	universities	• Trust companies
	• Cultural centers	
BURIAL	• Exhibition halls	**INDUSTRIES, FACTORIES**
	• Lecture halls	
• Cemeteries, mausoleums	• Libraries	• Automobile manufacturers
• Funeral homes	• Museums of all types	• Building equipment and supplies
• Pet cemeteries	• Music schools	• Building manufacturers
	• Newspaper facilities	• Carpet industry
BUSINESS SERVICES	• Photography shops	• Cleaning industry
• Auction houses	• Publishing houses	• Clothing industry
• Automobile rental agencies	• Research centers	• Commercial industry
• Building maintenance and repair	**ENTERTAINMENT-SPORT CENTERS**	• Dumping areas
		• Film industry
	Bars and taverns	• Food industry
• Data processing offices	•	• Furniture manufacturers
• Distribution services	• Bowling alleys	• Processing plants
• Employment services	• Boxing arenas	• Recording industry
• Equipment, other rental services	• Broadcasting centers	• Tailors
	• Cinema (movie theaters)	• Textile industry
• Firefighting services	• Football, basketball, tennis centers	• Wine industry
• Moving companies		
• Packing and shipping	• Gambling casinos	**MEDICAL CENTERS**
• Pet grooming services	• Gymnastics centers	• Animal hospitals
• Police headquarters	• Music shops	• Clinics
• Post office	• Opera and concert halls	• Health care equipment
• Rental agencies, real estate	• Party halls Pool halls	• Hospitals, surgery rooms
• Resume writing services	• Public gathering halls	• Human service organizations Medical
• School supplies	• Skating rinks: roller, ice	• laboratories
• Some office buildings	• Social clubs of all types	• Pharmacy and drug centers
• Travel agencies	• Sports arenas	• Physicians' offices
	• Sports clubs of all types	• Rehabilitation centers
		. Shelters
CREATIVE WORK	• Swimming pools	• Social service organizations
	• Table tennis, indoor courts	
• Art galleries	• Tennis and badminton courts	
• Artist display shops		
• Artists' painting supplies		

Utilization of underground space could reduce surface congestion in central business districts; provide efficient facilities for bulk storage, as well as for the storage of hazardous materials and wastes (Ray 1998).

Subsurface construction is technically viable and has fewer problems with land expropriation and environmental impacts, which are major points of considerations in any development projects today. Because of the higher construction cost, underground space development is a better option in the long run (Phienwej 1998).

In short, the advantages of compact cities that would make use of subsurface space;

- more efficient use of space;
- locational proximity;
- better traffic mobility;
- more green areas;
- provide security against toxic and hazardous materials;
- protection against severe whether;
- reduced traffic congestion;
- provide security because of limited access;
- better air quality;
- more efficient use of energy because of cool and stable climate;
- reduced noise level;
- thermal isolation;
- reduced risk against seismic waves.

This means that by building underground, the quality of the urban environment can be significantly improved and valuable space is provided without horizontal expansion.

Although building underground is not new especially for many countries, it still seems to be an unfamiliar subject for the others, because of its negative psychological aspects. Some of the aspects with the underground are;

- darkness combined with humid air;
- a high initial cost to construct the facility;
- a high operational cost for underground transport facilities;
- a concern for the risk of unforeseen underground conditions that will delay construction and increase costs.
- fear of entrapment from structural collapse;

- disorientation;
- loss of connection with the natural world;
- lack of natural light and poor ventilation.

It is important that broad generalizations about advantages and disadvantages are not possible. Typical disadvantages may not be valid for all types of facilities and locations. For example, underground facilities would cost less than equivalent surface facilities in some circumstances; operational and maintenance costs would be far less for an appropriate type of facility and construction risk can be ameliorated by careful preplanning and investigation (Sterling 1997). Today's technology has been able to cope with and overcome many of the mentioned aspects effectively and efficiently. Additionally, compared to aboveground structures, underground structures are more secure and safe places in case of seismic activity. Integrated planning of above and underground building reduces significantly investment costs. Partial placement of public transport (highways and railways) underground provides more continuous city development (no physical barrier or spatial segregation). Clear separation of pedestrians and traffic provides less confusion and better mobility for each group.

Building underground can improve our urban environment by relieving the pressure on the surface, developing better public-transport networks, reducing noise, leaving more green areas in city centers and reducing distances by better concentration of functions (Durmusevic 1999). Achieving more compact cities can become an important part of sustainable development, because of its significant advantages that summarized below;

Table 4.27. Pros and Cons of the Geo-Space City
(Source: Golany 1996)

Historical

Pros

- Use of the geo-space in large scale has proved to be feasible and can offer clues for future development
- Historical designs provide impetus for innovation in contemporary practice to meet modem norms and standards

Cons

- Although individual historical cases have achieved their ultimate goals, their norms of design cannot be an example for our contemporary times, which require sunshine, natural light, ventilation, and other environmental needs

Land use

Pros

- Introduces natural environment deep into the city when moving urban arteries into the geo-space
- Preserves the beauty of nature Provides dual land use for supra- and geo-space
- Enhances integrated land use to fuse the existing supra-space city with the geo-space city
- Creates proximity of land uses for daily needs
- Offers more comfort to the users through mixed integrated land use
- Total separation of transportation significantly reduces the human friction with transportation network
- Shortens all urban utility networks
- Consumes fewer building materials
- Floors have increased load capacity
- Compact land use reduces energy consumption
- Improves agricultural and poultry production

Cons

- Intensifies land use and may introduce congestion
- Congestion may lead to loss of some privacy, which may not be acceptable to some cultures

Social

Pros

- Enhances social interaction among age groups through the introduction of mixed and proximate land uses
- Enhances social urbanity
- Encourages social integration among heterogeneous groups and reduces isolation

Cons

- Cultural bias may cause acclimatization difficulties among heterogeneous groups
- May cause possible claustrophobia and psychological constraints, which necessitate special design
- Difficulty in eliminating psychological resentment against belowground space
- Requires adaptability

Economic

(Cont. on next page)

Table 4.27. (cont.)

Pros

- Dual land use reduces urban land cost
- Slows speculation of city land prices
- Compactness brought to the geo-space city reduces the complexity of the infrastructure and expenditure in its design, construction, and maintenance
- Increases housing options and employment
- Heat gain and loss are minimal; lower energy consumption
- Provides low-cost refrigeration
- Increases labor productivity by comfortable and stable air temperature
- Lessens speculation of city land uses

Cons

- Increases costs of pumping water
- Initial investment costs are high
- Land prices may escalate after initial development is made
- New design may be costly and require research
- Costs during construction may be high
- Illumination may increase maintenance costs
- Possible need for blasting may increase costs
- Geological and soil mapping costs are involved
- Extensive excavation may require costly reclamation of land surface to refit it for agricultural and other uses

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Transportation

Pros

- Increases the usage of nonpolluting mass transportation, such **as** subways
- Reduces the use of private transportation Shortens commuting time

Cons

- Creates a major change in the urban system
- Carries a risk of transportation vibration from heavy vehicles

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Safety

Pros

- Provides protection from manmade and natural disasters
- Water utilities will not freeze burst, etc.
- Increases resistance to fire
- Minimizes flood risk due to slope structure for dwellings
- Protects against earthquakes with responsive design measures and proper site selection
- Protects against tornadoes, hurricanes, and electrical storms

Cons

- Have fire evacuation difficulties
- Geological faults increase risk of impacts from earthquakes

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(Cont. on next page)

Table 4.27. (cont.)

Environment

Pros

- Minimizes impact on the natural environment
- Creates a pleasing and generous relaxing urban environment affiliated with daily city land uses
- Provides a livable urbanity, yet active city
- Provides a stimulating environment for creativity of writers and artists

Cons

- May introduce some environmental constraints and require adjustments
- Noise levels, generated from gathering in public spaces, may increase
- Has potential exposure to radon
- Special indoor landscape is needed for some spaces

Quality of Life

Pros

- All transportation is moved below ground
- Provides a wide natural environment in the with pleasing green spaces
- Eases mental pressure on individuals and groups
- Brings proximity to diversified land uses
- Provides cleaner and fresher air
- Introduces wide, safe pedestrian networks throughout the city, totally separated from motorways
- Reduces transportation noise and air pollution, is quiet, and provides safety

Cons

- In a closed environment, air pollution may become a problem unless passive or active city ventilation is designed or electric cars a common reality groups

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Health

Pros

- Comfortable ambient temperature supports relaxation and mental vitality
- Quietness stimulates creativity
- Minimizes visual and audible distractions
- Reduces the post-surgery healing period by 20 percent
- Tranquility reduces stress

Cons

- Increases dampness, especially in humid regions
- Potentially induces claustrophobia
- May require passive or active ventilation design

Climatic Comfort

Pros

- Increases weatherproofing against extreme and stressful climate
- Introduces stable seasonal and diurnal temperature and is beneficial for health and for some industry
- Resists temperature fluctuation and contributes to a comfortable ambient environment
- In extreme cold climates, survival is still assured when electricity or heat is interrupted
- Reduces impact of wind significantly

(Cont. on next page)

Table 4.27. (cont.)

Cons

- Risk of cover by dust storms in some regions

Maintenance Cost

Pros

- Lowers maintenance costs
- Extends durability of structures
- Housekeeping is reduced
- Fire insurance rates should be lower
- Proximity of land uses reduces utility costs significantly

Cons

- Increases costs of pumping water to the sloped dwellings and pumping waste from the pit units

4.6. Evaluation of "Model Building by-law" in terms of Land Consumption

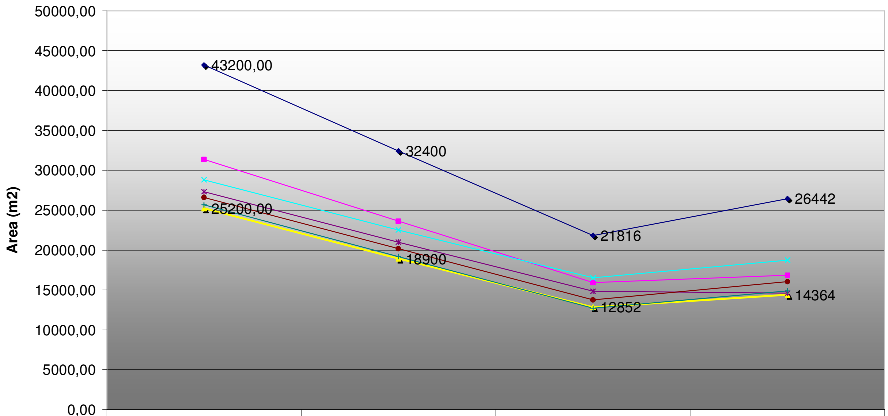
The way creating sustainable urban development pattern that claimed by Expert Group of European Commission is reducing, reusing and recycling of natural resources such as; air, water, land. For that reason creating compact urban built environment is the major strategy because of its great efficient land use pattern in terms of land consumption. Current implementations of urban residential areas that guided by model building by-law studied and evaluated for defining to what extent different building types would provide efficient land use pattern in terms of total area consumption and their perimeter length. At first place, building blocks that contain 10 to 400 dwelling units designed for four types of building type and their area and perimeter values compared in Table 4.28

For subdivision plans, model building by-law describes four different building type (up to 8) storey;

- Detached type of building;
- Semi-detached type of building;
- Terraced type of building;
- Block type of building.

In the first place, statistical graphic analyses that compare area values of building blocks performed between type of buildings (detached, semi-detached, terraced and block) and number of storey (2, 3, 4, …8) then, this comparison performed between number of units and number of storey.

Area Comparison for Building Types (400 Units)



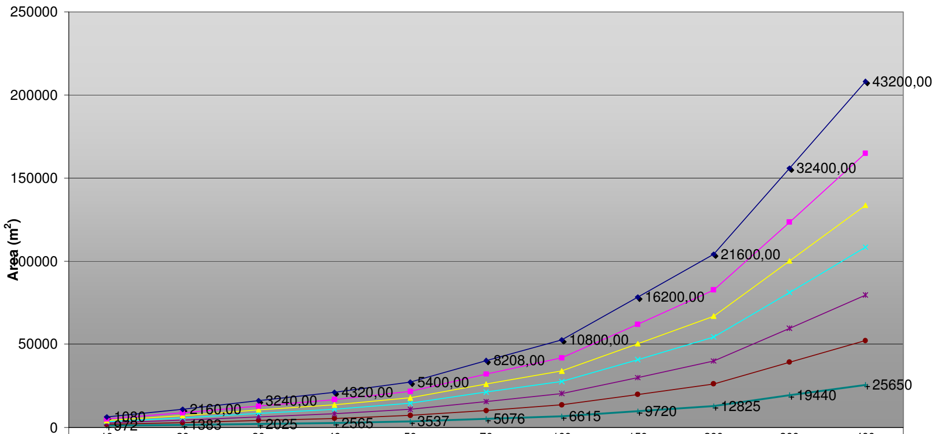
BuildingTypes	DETACHED	SEMI-DETACHED	TERRACED	APARTMENT BLOCK
2 storey 400 units	43200,00	32400	21816	26442
3 storey 400 units	31356,00	23634	15912	16848
4 storey 400 units	25200,00	18900	12852	14364
5 storey 400 units	28800,00	22500	16515	18720
6 storey 400 units	27312	20976	14832	14592
7 storey 400 units	26583,75	20157,75	13731,75	16033,5
8 storey 400 units	25650	19170	12690	14850

BuildingTypes

Figure 4.17.Area comparison for different building type

For land consumption comparison, building blocks that contain 10 and 400 units of dwelling have the similar graphical values. Compared to different building types with respect to area values, surprisingly 4 storey terraced type of building development has the minimum land coverage area. But 5 storey building type has approximate values with the 3 storey development type.

Area Comparasion for Detached Type Housing

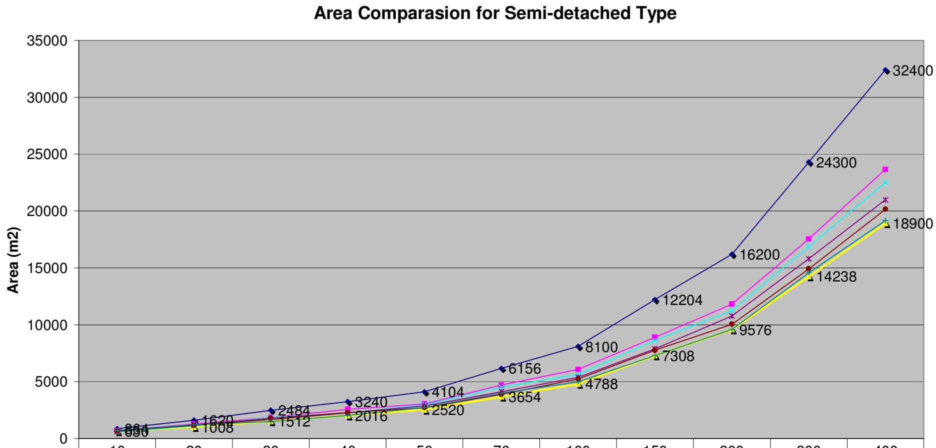


Number of Units	10	20	30	40	50	76	100	150	200	300	400
2 storey	1080	2160,00	3240,00	4320,00	5400,00	8208,00	10800,00	16200,00	21600,00	32400,00	43200,00
3 storey	936	1638,00	2340,00	3276,00	3978,00	6084,00	7956,00	11700,00	15678,00	23400,00	31356,00
4 storey	756	1260,00	2016,00	2520,00	3285,00	4788,00	6300,00	9576,00	12600,00	18900,00	25200,00
5 storey	720	1440,00	2160,00	2880,00	3600,00	5760,00	7200,00	10800,00	14400,00	21600,00	28800,00
6 storey	792	1608	2040	2832	3648	5280	6912	10200	13848	20400	27312
7 storey	879,75	1377	2256,75	2728,5	3633,75	5049	6846,75	10059,75	13298,25	19737	26583,75
8 storey	972	1383	2025	2565	3537	5076	6615	9720	12825	19440	25650

Number of Units

Figure 4.18. Area comparison for detached type housing

For detached buildings type development, total area values for 10 to 400 units shows linear increase and as expected 2 storey development has maximum values. 8 storey development provide maximum land saving.

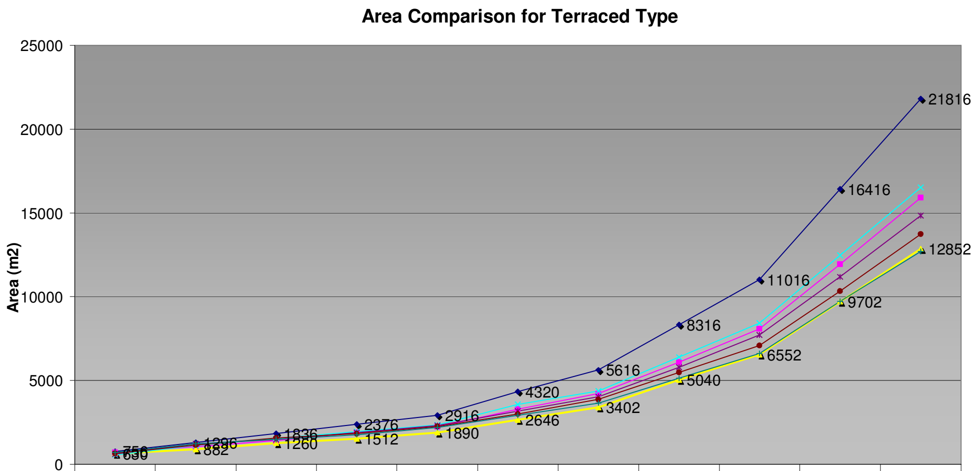


	10	20	30	40	50	76	100	150	200	300	400
2 storey	864	1620	2484	3240	4104	6156	8100	12204	16200	24300	32400
3 storey	702	1287	1872	2574	3042	4680	6084	8892	11817	17550	23634
4 storey	630	1008	1512	2016	2520	3654	4788	7308	9576	14238	18900
5 storey	562	1125	1845	2250	2970	4500	5625	8595	11250	16875	22500
6 storey	600	1224	1656	2256	2880	4128	5376	7896	10776	15792	20976
7 storey	650,25	1147,5	1797,75	2269,5	2715,75	3888,75	5240,25	7764,75	10059,75	14917,5	20157,75
8 storey	702	1215	1485	2025	2727	3996	4995	7290	9585	14580	19170

Number of Units

Figure 4.19. Area Comparison for semi-detached type housing

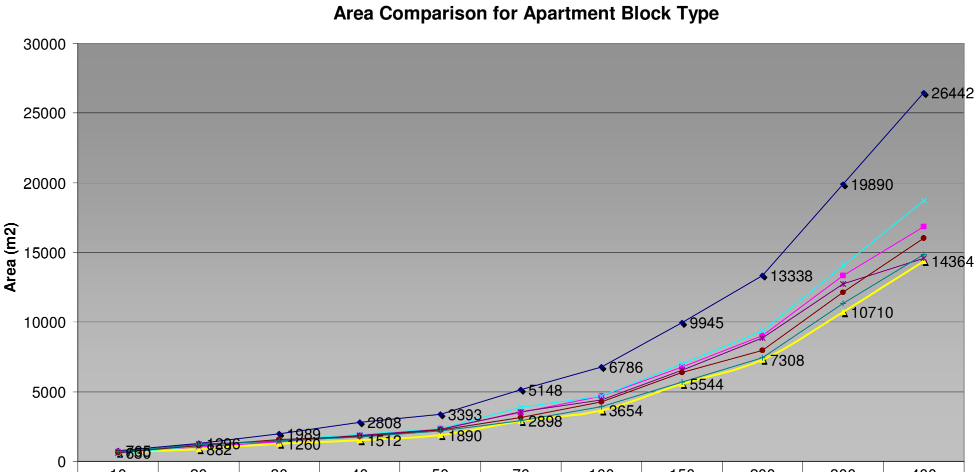
As previous results of comparisons 4 storey semi-detached development has minimum area values and also values of 5 storey development has higher value than 6, 7, 8 storey development.



	10	20	30	40	50	76	100	150	200	300	400
2 storey	756	1296	1836	2376	2916	4320	5616	8316	11016	16416	21816
3 storey	702	1053	1404	1872	2223	3276	4212	6084	8073	11934	15912
4 storey	630	882	1260	1512	1890	2646	3402	5040	6552	9702	12852
5 storey	562	1125	1530	1935	2340	3555	4365	6390	8415	12465	16515
6 storey	600	1224	1464	1872	2304	3168	4032	5784	7704	11184	14832
7 storey	650,25	1134,75	1568,25	1810,5	2256,75	2983,5	3863,25	5469,75	7076,25	10314,75	13731,75
8 storey	702	1215	1485	1755	2187	2916	3645	5130	6615	9720	12690

Number of Units

Figure 4.20. Area comparison for terraced type of development



Number of Unit	10	20	30	40	50	76	100	150	200	300	400
2 storey	765	1296	1989	2808	3393	5148	6786	9945	13338	19890	26442
3 storey	702	1053	1404	1872	2340	3510	4680	6786	9009	13338	16848
4 storey	630	882	1260	1512	1890	2898	3654	5544	7308	10710	14364
5 storey	562	1125	1530	1935	2340	3870	4680	7020	9360	14040	18720
6 storey	600	1248	1464	1872	2304	3552	4416	6552	8856	12720	14592
7 storey	650,25	1134,75	1568,25	1810,5	2256,75	3161,6	4277,25	6387,75	7960,5	12138	16033,5
8 storey	702	1215	1485	1755	2187	2928	3923,75	5700	7425	11340	14850

Number of Unit

Figure 4.21. Area comparison for block type of development

For terraced and block type of development 4 storey development yet again has minimum values in terms of land consumption, however the values of 5 storey development are surprisingly higher than 3 storey development.

Table 4.28. Comparison Between Varied Building Types according to Model Building by-law

Table 4.28. Comparison Between Varied Building Types according to Model Building by-law

		DETACHED (dublex or triplex)				DETACHED						SEMI-DETACHED					
										decrease rate based to detached dublex or triplex						decrease rate based to detached	
2 Storey	incr.rate	AREA	incr. rate	PERIMETER	incr. rate	AREA	incr rate	PERIMETER	incr. rate	AREA	PERIMETER	AREA	incr. rate	PERIMETER	incr. rate	AREA	PERIMETER
Number of Units																	
10		2340		198		1080		144		0,46	0,73	864		132		0,80	0,92
20	2,00	4680	2,00	318	1,61	2160,00	2,00	192,00	1,33	0,46	0,60	1620	1,88	180	1,36	0,75	0,94
30	1,50	7020	1,50	438	1,38	3240,00	1,50	264,00	1,38	0,46	0,60	2484	1,53	216	1,20	0,77	0,82
40	1,33	9360	1,33	558	1,27	4320,00	1,33	312,00	1,18	0,46	0,56	3240	1,30	252	1,17	0,75	0,81
50	1,25	11700	1,25	678	1,22	5400,00	1,25	384,00	1,23	0,46	0,57	4104	1,27	312	1,24	0,76	0,81
76	1,52	17784	1,52	990	1,46	8208,00	1,52	528,00	1,38	0,46	0,53	6156	1,50	432	1,38	0,75	0,82
100	1,32	23400	1,32	1278	1,29	10800,00	1,32	672,00	1,27	0,46	0,53	8100	1,32	540	1,25	0,75	0,80
150	1,50	35100	1,50	1878	1,47	16200,00	1,50	984,00	1,46	0,46	0,52	12204	1,51	756	1,40	0,75	0,77
200	1,33	46800	1,33	2478	1,32	21600,00	1,33	1272,00	1,29	0,46	0,51	16200	1,33	972	1,29	0,75	0,76
300	1,50	70200	1,50	3678	1,48	32400,00	1,50	1872,00	1,47	0,46	0,51	24300	1,50	1440	1,48	0,75	0,77
400	1,33	93600	1,33	4878	1,33	43200,00	1,33	2472,00	1,32	0,46	0,51	32400	1,33	1872	1,30	0,75	0,76
3 Storey																	
10		2340		198		936		126		0,40	0,64	702		114		0,75	0,90
20	2,00	4680	2,00	318	1,61	1638,00	1,75	174,00	1,38	0,35	0,55	1287	1,83	150	1,32	0,79	0,86
30	1,50	7020	1,50	438	1,38	2340,00	1,43	198,00	1,14	0,33	0,45	1872	1,45	174	1,16	0,80	0,88
40	1,33	9360	1,33	558	1,27	3276,00	1,40	246,00	1,24	0,35	0,44	2574	1,38	210	1,21	0,79	0,85
50	1,25	11700	1,25	678	1,22	3978,00	1,21	294,00	1,20	0,34	0,43	3042	1,18	246	1,17	0,76	0,84
76	1,52	17784	1,52	990	1,46	6084,00	1,53	390,00	1,33	0,34	0,39	4680	1,54	318	1,29	0,77	0,82
100	1,32	23400	1,32	1278	1,29	7956,00	1,31	486,00	1,25	0,34	0,38	6084	1,30	390	1,23	0,76	0,80
150	1,50	35100	1,50	1878	1,47	11700,00	1,47	678,00	1,40	0,33	0,36	8892	1,46	534	1,37	0,76	0,79
200	1,33	46800	1,33	2478	1,32	15678,00	1,34	894,00	1,32	0,34	0,36	11817	1,33	690	1,29	0,75	0,77
300	1,50	70200	1,50	3678	1,48	23400,00	1,49	1278,00	1,43	0,33	0,35	17550	1,49	978	1,42	0,75	0,77
400	1,33	93600	1,33	4878	1,33	31356,00	1,34	1686,00	1,32	0,34	0,35	23634	1,35	1290	1,32	0,75	0,77
Decrease rate based to 2 storey 10						0,87		0,88				0,81		0,86			
20						0,76		0,91				0,79		0,83			
30						0,72		0,75				0,75		0,81			
40						0,76		0,79				0,79		0,83			
50						0,74		0,77				0,74		0,79			
76						0,74		0,74				0,76		0,74			
100						0,74		0,72				0,75		0,72			
150						0,72		0,69				0,73		0,71			
200						0,73		0,70				0,73		0,71			
300						0,72		0,68				0,72		0,68			
400						0,73		0,68				0,73		0,69			
4 Storey																	
10						756		132				630		120		0,83	0,91
20	2,00					1260,00	1,67	156,00	1,18			1008	1,60	144	1,20	0,80	0,92
30	1,50					2016,00	1,60	180,00	1,15			1512	1,50	156	1,08	0,75	0,87
40	1,33					2520,00	1,25	204,00	1,13			2016	1,33	180	1,15	0,80	0,88
50	1,25					3285,00	1,30	253,00	1,24			2520	1,25	216	1,20	0,77	0,85
76	1,52					4788,00	1,46	324,00	1,28			3654	1,45	264	1,22	0,76	0,81
100	1,32					6300,00	1,32	396,00	1,22			4788	1,31	324	1,23	0,76	0,82
150	1,50					9576,00	1,52	540,00	1,36			7308	1,53	432	1,33	0,76	0,80
200	1,33					12600,00	1,32	684,00	1,27			9576	1,31	540	1,25	0,76	0,79
300	1,50					18900,00	1,50	996,00	1,46			14238	1,49	768	1,42	0,75	0,77
400	1,33					25200,00	1,33	1284,00	1,29			18900	1,33	984	1,28	0,75	0,77
Decrease rate based to 2 storey 10						0,70		0,92				0,73		0,91			
20						0,58		0,81				0,62		0,80			
30						0,62		0,68				0,61		0,72			
40						0,58		0,65				0,62		0,71			
50						0,61		0,66				0,61		0,69			
76						0,58		0,61				0,59		0,61			
100						0,58		0,59				0,59		0,60			
150						0,59		0,55				0,60		0,57			
200						0,58		0,54				0,59		0,56			
300						0,58		0,53				0,59		0,53			
400						0,58		0,52				0,58		0,53			
5 Storey																	
10						720		122				562		95		0,78	0,78
20	2,00					1440,00	2,00	154,00	1,26			1125	2,00	140	1,47	0,78	0,91
30	1,50					2160,00	1,50	186,00	1,21			1845	1,64	172	1,23	0,85	0,92
40	1,33					2880,00	1,33	218,00	1,17			2250	1,22	190	1,10	0,78	0,87
50	1,25					3600,00	1,25	250,00	1,15			2970	1,32	222	1,17	0,83	0,89
76	1,52					5760,00	1,60	346,00	1,38			4500	1,52	290	1,31	0,78	0,84
100	1,32					7200,00	1,25	410,00	1,18			5625	1,25	340	1,17	0,78	0,83
150	1,50					10800,00	1,50	570,00	1,39			8595	1,53	472	1,39	0,80	0,83
200	1,33					14400,00	1,33	730,00	1,28			11250	1,31	590	1,25	0,78	0,81
300	1,50					21600,00	1,50	1050,00	1,44			16875	1,50	840	1,42	0,78	0,80
400	1,33					28800,00	1,33	1370,00	1,30			22500	1,33	1090	1,30	0,78	0,80
Decrease rate based to 2 storey 10						0,67		0,85				0,65		0,72			
20						0,67		0,80				0,69		0,78			
30						0,67		0,70				0,74		0,80			
40						0,67		0,70				0,69		0,75			
50						0,67		0,65				0,72		0,71			
76						0,70		0,66				0,73		0,67			
100						0,67		0,61				0,69		0,63			
150						0,67		0,58				0,70		0,62			
200						0,67		0,57				0,69		0,61			
300						0,67		0,56				0,69		0,58			
400						0,67		0,55				0,69		0,58			
6 Storey																	
10						792		130				600		98		0,76	0,75
20	2,00					1608	2,03	164	1,26			1224	2,04	148	1,51	0,76	0,90
30	1,50					2040	1,27	198	1,21			1656	1,35	182	1,23	0,81	0,92
40	1,33					2832	1,39	230	1,16			2256	1,36	198	1,09	0,80	0,86
50	1,25					3648	1,29	264	1,15			2880	1,28	232	1,17	0,79	0,88
76	1,52					5280	1,45	332	1,26			4128	1,43	284	1,22	0,78	0,86
100	1,32					6912	1,31	400	1,20			5376	1,30	336	1,18	0,78	0,84
150	1,50					10200	1,48	538	1,35			7896	1,47	442	1,32	0,77	0,82
200	1,33					13848	1,36	674	1,25			10776	1,36	546	1,24	0,78	0,81
300	1,50					20400	1,47	946	1,40			15792	1,47	754	1,38	0,77	0,80
400	1,33					27312	1,34	1250	1,32			20976	1,33	978	1,30	0,77	0,78
Decrease rate based to 2 storey 10						0,73		0,90				0,69		0,74			
20						0,74		0,85				0,76		0,82			
30						0,63		0,75				0,67		0,84			
40						0,66		0,74				0,70		0,79			
50						0,68		0,69				0,70		0,74			
76						0,64		0,63				0,67		0,66			
100						0,64		0,60				0,66		0,62			
150						0,63		0,55				0,65		0,58			
200						0,64		0,53				0,67		0,56			
300						0,63		0,51				0,65		0,52			
400						0,63		0,51				0,65		0,52			
7 Storey																	
10						879,75		120				650,25		102		0,74	0,85
20	2,00					1377	1,57	174	1,45			1147,5	1,76	156	1,53	0,83	0,90
30	1,50					2256,75	1,64	207	1,19			1797,8	1,57	189	1,21	0,80	0,91
40	1,33					2728,5	1,21	210	1,01			2269,5	1,26	192	1,02	0,83	0,91
50	1,25					3633,75	1,33	246	1,17			2715,8	1,20	210	1,09	0,75	0,85
76	1,52					5049	1,39	318	1,29			3888,8	1,43	264	1,26	0,77	0,83
100	1,32					6846,75	1,36	387	1,22			5240,3	1,35	318	1,20	0,77	0,82
150	1,50					10059,75	1,47	498	1,29			7764,8	1,48	408	1,28	0,77	0,82
200	1,33					13298,25	1,32	641	1,29			10060	1,30	513	1,26	0,76	0,80
300	1,50					19737	1,48	894	1,39			14918	1,48	696	1,36	0,76	0,78
400	1,33					26583,75	1,35	1146	1,28			20158	1,35	894	1,28	0,76	0,78
Decrease rate based to 2 storey 10						0,81		0,83				0,75		0,77			
20						0,64		0,91				0,71		0,87			
30						0,70		0,78				0,72		0,88			
40						0,63		0,67				0,70		0,76			
50						0,67		0,64				0,66		0,67			
76						0,62		0,60				0,63		0,61			
100						0,63		0,58				0,65		0,59			
150						0,62		0,51				0,64		0,54			
200						0,62		0,50				0,62		0,53			
300						0,61		0,48				0,61		0,48			
400						0,62		0,46				0,62		0,48			
8 Storey																	
10						972		126				702		106		0,72	0,84
20	2,00					1383	1,42	172	1,37			1215	1,73	164	1,55	0,88	0,95
30	1,50					2025	1,46	184	1,07			1485	1,22	164	1,00	0,73	0,89
40	1,33					2565	1,27	222	1,21			2025	1,36	202	1,23	0,79	0,91
50	1,25					3537	1,38	256	1,15			2727	1,35	216	1,07	0,77	0,84
76	1,52					5076	1,44	298	1,16			3996	1,47	258	1,19	0,79	0,87
100	1,32					6615	1,30	370	1,24			4995	1,25	310	1,20	0,76	0,84
150	1,50					9720	1,47	486	1,31			7290	1,46	388	1,25	0,75	0,80
200	1,33					12825	1,32	602	1,24			9585	1,31	482	1,24	0,75	0,80
300	1,50					19440	1,52	830	1,38			14580	1,52	650	1,35	0,75	0,78
400	1,33					25650	1,32	1058	1,27			19170	1,31	818	1,26	0,75	0,77
Decrease rate based to 2 storey 10						0,90		0,88				0,81		0,80			
20						0,64		0,90				0,75		0,91			
30						0,63		0,70				0,60		0,76			
40						0,59		0,71				0,63		0,80			
50						0,66		0,67				0,66		0,69			
76						0,62		0,56				0,65		0,60			
100						0,61		0,55				0,62		0,57			
150						0,60		0,49				0,60		0,51			
200						0,59		0,47				0,59		0,50			
300						0,60		0,44				0,60		0,45			
400						0,59		0,43				0,59		0,44			

	TERRACED						APARTMENT BLOCK						Evaluation of Decrease rates					
					decrease rate based to detached						decrease rate based to detached							
2 Storey	AREA	incr. rate	PERIMETER	incr. rate	AREA	PERIMETER	AREA	incr. rate	PERIMETER	incr. rate	AREA	PERIMETER	average		min		max	
Number of Units													area	perimeter	area	perimeter	area	perimeter
10	756		120		0,70	0,83	765		120		0,71	0,83	0,67	0,83	0,46	0,73	0,80	0,92
20	1296	1,71	144	1,20	0,60	0,75	1296	1,69	144	1,20	0,60	0,75	0,60	0,76	0,46	0,60	0,75	0,94
30	1836	1,42	180	1,25	0,57	0,68	1989	1,53	186	1,29	0,61	0,70	0,60	0,70	0,46	0,60	0,77	0,82
40	2376	1,29	204	1,13	0,55	0,65	2808	1,41	300	1,61	0,65	0,96	0,60	0,75	0,46	0,56	0,75	0,96
50	2916	1,23	240	1,18	0,54	0,63	3393	1,21	336	1,12	0,63	0,88	0,60	0,72	0,46	0,57	0,76	0,88
76	4320	1,48	312	1,30	0,53	0,59	5148	1,52	498	1,48	0,63	0,94	0,59	0,72	0,46	0,53	0,75	0,94
100	5616	1,30	384	1,23	0,52	0,57	6786	1,32	660	1,33	0,63	0,98	0,59	0,72	0,46	0,53	0,75	0,98
150	8316	1,48	540	1,41	0,51	0,55	9945	1,47	906	1,37	0,61	0,92	0,59	0,69	0,46	0,52	0,75	0,92
200	11016	1,32	684	1,27	0,51	0,54	13338	1,34	1230	1,36	0,62	0,97	0,58	0,70	0,46	0,51	0,75	0,97
300	16416	1,49	984	1,44	0,51	0,53	19890	1,49	1800	1,46	0,61	0,96	0,58	0,69	0,46	0,51	0,75	0,96
400	21816	1,33	1284	1,30	0,51	0,52	26442	1,33	2370	1,32	0,61	0,96	0,58	0,69	0,46	0,51	0,75	0,96
3 Storey																		
10	702		114		0,75	0,90	702		114		0,75	0,90	0,66	0,84	0,40	0,64	0,75	0,90
20	1053	1,50	138	1,21	0,64	0,79	1053	1,50	138	1,21	0,64	0,79	0,61	0,75	0,35	0,55	0,79	0,86
30	1404	1,33	150	1,09	0,60	0,76	1404	1,33	150	1,09	0,60	0,76	0,58	0,71	0,33	0,45	0,80	0,88
40	1872	1,33	174	1,16	0,57	0,71	1872	1,33	174	1,16	0,57	0,71	0,57	0,68	0,35	0,44	0,79	0,85
50	2223	1,19	198	1,14	0,56	0,67	2340	1,25	249	1,43	0,59	0,85	0,56	0,70	0,34	0,43	0,76	0,85
76	3276	1,47	246	1,24	0,54	0,63	3510	1,50	336	1,35	0,58	0,86	0,56	0,68	0,34	0,39	0,77	0,86
100	4212	1,29	294	1,20	0,53	0,60	4680	1,33	474	1,41	0,59	0,98	0,56	0,69	0,34	0,38	0,76	0,98
150	6084	1,44	390	1,33	0,52	0,58	6786	1,45	660	1,39	0,58	0,97	0,55	0,67	0,33	0,36	0,76	0,97
200	8073	1,33	498	1,28	0,51	0,56	9009	1,33	858	1,30	0,57	0,96	0,54	0,66	0,34	0,36	0,75	0,96
300	11934	1,48	690	1,39	0,51	0,54	13338	1,48	1230	1,43	0,57	0,96	0,54	0,65	0,33	0,35	0,75	0,96
400	15912	1,33	894	1,30	0,51	0,53	16848	1,26	1614	1,31	0,54	0,96	0,53	0,65	0,34	0,35	0,75	0,96
Decrease rate based to 2 storey 10	0,93		0,95				0,92		0,95									
20	0,81		0,96				0,81		0,96									
30	0,76		0,83				0,71		0,81									
40	0,79		0,85				0,67		0,58									
50	0,76		0,83				0,69		0,74									
76	0,76		0,79				0,68		0,67									
100	0,75		0,77				0,69		0,72									
150	0,73		0,72				0,68		0,73									
200	0,73		0,73				0,68		0,70									
300	0,73		0,70				0,67		0,68									
400	0,73		0,70				0,64		0,68									
4 Storey																		
10	630		120		0,83	0,91	630		120		0,83	0,91	0,83	0,91	0,83	0,91	0,83	0,91
20	882	1,40	132	1,10	0,70	0,85	882	1,40	132	1,10	0,70	0,85	0,73	0,87	0,70	0,85	0,80	0,92
30	1260	1,43	144	1,09	0,63	0,80	1260	1,43	144	1,09	0,63	0,80	0,67	0,82	0,63	0,80	0,75	0,87
40	1512	1,20	156	1,08	0,60	0,76	1512	1,20	156	1,08	0,60	0,76	0,67	0,80	0,60	0,76	0,80	0,88
50	1890	1,25	180	1,15	0,58	0,71	1890	1,25	180	1,15	0,58	0,71	0,64	0,76	0,58	0,71	0,77	0,85
76	2646	1,40	216	1,20	0,55	0,67	2898	1,53	312	1,73	0,61	0,96	0,64	0,81	0,55	0,67	0,76	0,96
100	3402	1,29	252	1,17	0,54	0,64	3654	1,26	348	1,12	0,58	0,88	0,63	0,78	0,54	0,64	0,76	0,88
150	5040	1,48	324	1,29	0,53	0,60	5544	1,52	516	1,48	0,58	0,96	0,62	0,79	0,53	0,60	0,76	0,96
200	6552	1,30	396	1,22	0,52	0,58	7308	1,32	684	1,33	0,58	1,00	0,62	0,79	0,52	0,58	0,76	1,00
300	9702	1,48	552	1,39	0,51	0,55	10710	1,47	936	1,37	0,57	0,94	0,61	0,76	0,51	0,55	0,75	0,94
400	12852	1,32	696	1,26	0,51	0,54	14364	1,34	1272	1,36	0,57	0,99	0,61	0,77	0,51	0,54	0,75	0,99
Decrease rate based to 2 storey 10	0,83		1,00				0,82		1,00									
20	0,68		0,92				0,68		0,92									
30	0,69		0,80				0,63		0,77									
40	0,64		0,76				0,54		0,52									
50	0,65		0,75				0,56		0,54									
76	0,61		0,69				0,56		0,63									
100	0,61		0,66				0,54		0,53									
150	0,61		0,60				0,56		0,57									
200	0,59		0,58				0,55		0,56									
300	0,59		0,56				0,54		0,52									
400	0,59		0,54				0,54		0,54									
5 Storey																		
10	562		95		0,78	0,78	562		95		0,78	0,78	0,78	0,78	0,78	0,78	0,78	0,78
20	1125	2,00	140	1,47	0,78	0,91	1125	2,00	140	1,47	0,78	0,91	0,78	0,91	0,78	0,91	0,78	0,91
30	1530	1,36	158	1,13	0,71	0,85	1530	1,36	158	1,13	0,71	0,85	0,76	0,87	0,71	0,85	0,85	0,92
40	1935	1,26	176	1,11	0,67	0,81	1935	1,26	176	1,11	0,67	0,81	0,71	0,83	0,67	0,81	0,78	0,87
50	2340	1,21	194	1,10	0,65	0,78	2340	1,21	194	1,10	0,65	0,78	0,71	0,81	0,65	0,78	0,83	0,89
76	3555	1,52	248	1,28	0,62	0,72	3870	1,65	352	1,81	0,67	1,02	0,69	0,86	0,62	0,72	0,78	1,02
100	4365	1,23	284	1,15	0,61	0,69	4680	1,21	388	1,10	0,65	0,95	0,68	0,82	0,61	0,69	0,78	0,95
150	6390	1,46	374	1,32	0,59	0,66	7020	1,50	582	1,50	0,65	1,02	0,68	0,84	0,59	0,66	0,80	1,02
200	8415	1,32	464	1,24	0,58	0,64	9360	1,33	776	1,33	0,65	1,06	0,67	0,84	0,58	0,64	0,78	1,06
300	12465	1,48	644	1,39	0,58	0,61	14040	1,50	1164	1,50	0,65	1,11	0,67	0,84	0,58	0,61	0,78	1,11
400	16515	1,32	824	1,28	0,57	0,60	18720	1,33	1552	1,33	0,65	1,13	0,67	0,84	0,57	0,60	0,78	1,13
Decrease rate based to 2 storey 10	0,74		0,79				0,73		0,79									
20	0,87		0,97				0,87		0,97									
30	0,83		0,88				0,77		0,85									
40	0,81		0,86				0,69		0,59									
50	0,80		0,81				0,69		0,58									
76	0,82		0,79				0,75		0,71									
100	0,78		0,74				0,69		0,59									
150	0,77		0,69				0,71		0,64									
200	0,76		0,68				0,70		0,63									
300	0,76		0,65				0,71		0,65									
400	0,76		0,64				0,71		0,65									
6 Storey																		
10	600		98		0,76	0,75	600		98		0,76	0,75	0,76	0,75	0,76	0,75	0,76	0,75
20	1224	2,04	148	1,51	0,76	0,90	1248	2,08	148	1,51	0,78	0,90	0,77	0,90	0,76	0,90	0,78	0,90
30	1464	1,20	166	1,12	0,72	0,84	1464	1,17	166	1,12	0,72	0,84	0,75	0,87	0,72	0,84	0,81	0,92
40	1872	1,28	182	1,10	0,66	0,79	1872	1,28	182	1,10	0,66	0,79	0,71	0,81	0,66	0,79	0,80	0,86
50	2304	1,23	200	1,10	0,63	0,76	2304	1,23	200	1,10	0,63	0,76	0,68	0,80	0,63	0,76	0,79	0,88
76	3168	1,38	236	1,18	0,60	0,71	3552	1,54	348	1,74	0,67	1,05	0,68	0,87	0,60	0,71	0,78	1,05
100	4032	1,27	272	1,15	0,58	0,68	4416	1,24	384	1,10	0,64	0,96	0,67	0,83	0,58	0,68	0,78	0,96
150	5784	1,43	346	1,27	0,57	0,64	6552	1,48	570	1,48	0,64	1,06	0,66	0,84	0,57	0,64	0,77	1,06
200	7704	1,33	418	1,21	0,56	0,62	8856	1,35	754	1,32	0,64	1,12	0,66	0,85	0,56	0,62	0,78	1,12
300	11184	1,45	562	1,34	0,55	0,59	12720	1,44	1010	1,34	0,62	1,07	0,65	0,82	0,55	0,59	0,77	1,07
400	14832	1,33	722	1,28	0,54	0,58	14592	1,15	1192	1,18	0,53	0,95	0,62	0,77	0,53	0,58	0,77	0,95
Decrease rate based to 2 storey 10	0,79		0,82				0,78		0,82									
20	0,94		1,03				0,96		1,03									
30	0,80		0,92				0,74		0,89									
40	0,79		0,89				0,67		0,61									
50	0,79		0,83				0,68		0,60									
76	0,73		0,76				0,69		0,70									
100	0,72		0,71				0,65		0,58									
150	0,70		0,64				0,66		0,63									
200	0,70		0,61				0,66		0,61									
300	0,68		0,57				0,64		0,56									
400	0,68		0,56				0,55		0,50									
7 Storey																		
10	650,25		102		0,74	0,85	650,25		102		0,74	0,85	0,74	0,85	0,74	0,85	0,74	0,85
20	1134,8	1,75	156	1,53	0,82	0,90	1134,75	1,75	156	1,53	0,82	0,90	0,83	0,90	0,82	0,90	0,83	0,90
30	1568,3	1,38	174	1,12	0,69	0,84	1568,25	1,38	174	1,12	0,69	0,84	0,73	0,86	0,69	0,84	0,80	0,91
40	1810,5	1,15	174	1,00	0,66	0,83	1810,5	1,15	174	1,00	0,66	0,83	0,72	0,86	0,66	0,83	0,83	0,91
50	2256,8	1,25	192	1,10	0,62	0,78	2256,75	1,25	192	1,10	0,62	0,78	0,66	0,80	0,62	0,78	0,75	0,85
76	2983,5	1,32	228	1,19	0,59	0,72	3161,6	1,40	291,9	1,52	0,63	0,92	0,66	0,82	0,59	0,72	0,77	0,92
100	3863,3	1,29	261	1,14	0,56	0,67	4277,25	1,35	381	1,31	0,62	0,98	0,65	0,83	0,56	0,67	0,77	0,98
150	5469,8	1,42	318	1,22	0,54	0,64	6387,75	1,49	558	1,46	0,63	1,12	0,65	0,86	0,54	0,64	0,77	1,12
200	7076,3	1,29	387	1,22	0,53	0,60	7960,5	1,25	627	1,12	0,60	0,98	0,63	0,79	0,53	0,60	0,76	0,98
300	10315	1,46	515	1,33	0,52	0,58	12138	1,52	995	1,59	0,61	1,11	0,63	0,82	0,52	0,58	0,76	1,11
400	13732	1,33	642	1,25	0,52	0,56	16033,5	1,32	1242	1,25	0,60	1,08	0,63	0,81	0,52	0,56	0,76	1,08
Decrease rate based to 2 storey 10	0,86		0,85				0,85		0,85									
20	0,88		1,08				0,88		1,08									
30	0,85		0,97				0,79		0,94									
40	0,76		0,85				0,64		0,58									
50	0,77		0,80				0,67		0,57									
76	0,69		0,73				0,61		0,59									
100	0,69		0,68				0,63		0,58									
150	0,66		0,59				0,64		0,62									
200	0,64		0,57				0,60		0,51									
300	0,63		0,52				0,61		0,55									
400	0,63		0,50				0,61		0,52									
8 Storey																		
10	702		106		0,72	0,84	702		106		0,72	0,84	0,72	0,84	0,72	0,84	0,72	0,84
20	1215	1,73	164	1,55	0,88	0,95	1215	1,73	164	1,55	0,88	0,95	0,88	0,95	0,88	0,95	0,88	0,95
30	1485	1,22	164	1,00	0,73	0,89	1485	1,22	164	1,00	0,73	0,89	0,73	0,89	0,73	0,89	0,73	0,89
40	1755	1,18	182	1,11	0,68	0,82	1755	1,18	182	1,11	0,68	0,82	0,72	0,85	0,68	0,82	0,79	0,91
50	2187	1,25	196	1,08	0,62	0,77	2187	1,25	218	1,20	0,62	0,85	0,67	0,82	0,62	0,77	0,77	0,85
76	2916	1,33	218	1,11	0,57	0,73	2928	1,34	218	1,00	0,58	0,73	0,65	0,78	0,57	0,73	0,79	0,87
100	3645	1,25	250	1,15	0,55	0,68	3923,75	1,34	342,5	1,57	0,59	0,93	0,63	0,81	0,55	0,68	0,76	0,93
150	5130	1,41	308	1,23	0,53	0,63	5700	1,45	436	1,27	0,59	0,90	0,62	0,78	0,53	0,63	0,75	0,90
200	6615	1,29	362	1,18	0,52	0,60	7425	1,30	600	1,38	0,58	1,00	0,61	0,80	0,52	0,60	0,75	1,00
300	9720	1,47	470	1,30	0,50	0,57	11340	1,53	872	1,45	0,58	1,05	0,61	0,80	0,50	0,57	0,75	1,05
400	12690	1,31	578	1,23	0,49	0,55	14850	1,31	1090	1,25	0,58	1,03	0,61	0,78	0,49	0,55	0,75	1,03
Decrease rate based to 2 storey 10	0,93		0,88				0,92		0,88									
20	0,94		1,14				0,94		1,14									
30	0,81		0,91				0,75		0,88									
40	0,74		0,89				0,63		0,61									
50	0,75		0,82				0,64		0,65									
76	0,68		0,70				0,57		0,44									
100	0,65		0,65				0,58		0,52									
150	0,62		0,57				0,57		0,48									
200	0,60		0,53				0,56		0,49									
300	0,59		0,48				0,57		0,48									
400	0,58		0,45				0,56		0,46									

Regression analysis methods showed that area and perimeter values of all type of building blocks have a linear increase with the varied number of unit values and can be calculated with the formulas described below;

Table 4.29 Area and Perimeter Value Calculation Table for various building Type

2 storey apartment block area (m^2)	= 92, 63 + 65, 97 * **N. o U.**
apartment block perimeter (m)	= 47, 79 + 5, 83 * **N. o U.**
detached (area) (m^2)	= 0, 00 + 108 * **N. o U.**
detached (perimeter) (m)	= 78, 78 + 5, 98 * **N. o U.**
semi-detached (area) (m^2)	= 30, 52 + 80, 91 * **N. o U.**
semi-detached perimeter (m)	= 85, 66 + 4, 48 * **N. o U.**
terraced area (m^2)	= 216 + 54 * **N. o U.**
terraced (perimeter) (m)	= 87, 39 + 2, 99 * **N. o U.**
3 storey apartment block (area) (m^2)	= 287, 16 + 42, 43 * **N. o U.**
apartment block perimeter (m)	= 53, 20 + 3, 93 * **N. o U.**
detached (area) (m^2)	= 98, 47 + 77, 95 * **N. o U.**
detached (perimeter) (m)	= 87, 30 + 3, 99 * **N. o U.**
semi-detached (area) (m^2)	= 154, 28 + 58, 46 * **N. o U.**
semi-detached (perimeter) (m)	= 88, 93 + 2, 99* **N. o U.**
terraced (area) (m^2)	= 283, 23 + 38, 97 * **N. o U.**
terraced (perimeter) (m)	= 94, 65 + 1, 99 * **N. o U.**
4 storey apartment block (area) (m^2)	= 179, 90 + 35, 37 * **N. o U.**
4 storey apartment block (perimeter) (m)	= 60, 84 + 3, 00 * **N. o U.**
4 storey detached (area) (m^2)	= 72, 54 + 62, 79 * **N. o U.**
4 storey detached perimeter (m)	= 95, 89 + 2, 97 * **N. o U.**
4 storey semi-detached (area) (m^2)	= 130, 18 + 47, 03 * **N. o U.**
4 storey semi-detached (perimeter) (m)	= 96, 96 + 2, 22 * **N. o U.**
4 storey terraced (area) (m^2)	= 287, 60 + 31, 39 * **N. o U.**
4 storey terraced (perimeter) (m)	= 101, 87 + 1, 49 * **N. o U.**
5 storey apartment block (area) (m^2)	= 120, 44 + 46, 41 * **N. o U.**
5 storey apartment block (perimeter) (m)	= 38, 33 + 3, 75 * **N. o U.**
5 storey detached (area) (m^2)	= 37, 12 + 71, 91 * **N. o U.**
5 storey detached (perimeter) (m)	= 91, 65 + 3, 20 * **N. o U.**
5 storey semi-detached (area) (m^2)	= 89, 57 + 56, 04 * **N. o U.**
5 storey semi-detached (perimeter) (m)	= 90, 38 + 2, 50 * **N. o U.**
5 storey terraced (area) (m^2)	= 307, 45 + 40, 56 * **N. o U.**
5 storey terraced (perimeter) (m)	= 100, 07 + 1, 82 * **N. o U.**
6 storey apartment block (area) (m^2)	= 563, 68 + 37, 77 * **N. o U.**
6 storey apartment block (perimeter) (m)	= 91, 55 + 2, 94 * **N. o U.**
6 storey detached (area) (m^2)	= 138, 70 + 67, 84 * **N. o U.**
6 storey detached (perimeter) (m)	= 112, 95 + 2, 82 * **N. o U.**
6 storey semi-detached (area) (m^2)	= 162, 59 + 52, 16 * **N. o U.**
6 storey semi-detached (perimeter) (m)	= 109, 35 + 2, 18 * **N. o U.**
6 storey terraced (area) (m^2)	= 413, 75 + 36, 06 * **N. o U.**
6 storey terraced (perimeter) (m)	= 114, 82 + 1, 52 * **N. o U.**
7 storey apartment block (area) (m^2)	= 297, 05 + 39, 32 * **N. o U.**
7 storey apartment block (perimeter) (m)	= 74, 49 + 2, 96 * **N. o U.**
7 storey detached (area) (m^2)	= 185, 07 + 65, 71 * **N. o U.**
7 storey detached (perimeter) (m)	= 116, 32 + 2, 59 * **N. o U.**
7 storey semi-detached (area) (m^2)	= 219, 15 + 49, 56 * **N. o U.**
7 storey semi-detached (perimeter) (m)	= 113, 10 + 1, 96 * **N. o U.**
7 storey terraced (area) (m^2)	= 494, 96 + 33, 00 * **N. o U.**
7 storey terraced (perimeter) (m)	= 122, 35 + 1, 31 * **N. o U.**

(Cont. on next page)

Table 4.29.(cont.)

8 storey apartment block (area) (m^2)	= 331, 02 + 36, 24 * **N. o U.**
8 storey apartment block (perimeter) (m)	= 80, 66 + 2, 55 * **N. o U.**
8 storey detached (area) (m^2)	= 189, 47 + 63, 75 * **N. o U.**
8 storey detached (perimeter) (m)	= 123, 61 + 2, 36 * **N. o U.**
8 storey semi-detached (area) (m^2)	= 224, 44 + 47, 46 * **N. o U.**
8 storey semi-detached (perimeter) (m)	= 120, 74 + 1, 77 * **N. o U.**
8 storey terraced (area) (m^2)	= 566, 34 + 30, 40 * **N. o U.**
8 storey terraced (perimeter) (m)	= 130, 40 + 1, 14 * **N. o U.**
N. o U. = Number of Units	

Eventually, for the purpose of reducing land consumption and infrastructure length of future development pattern, type of building and number of storey are so critical for the size of urban macro-form. After all comparison of building types that described by "*model building by-law*", in terms of area consumption the most efficient building type for residential development is terraced type of building. On the contrary, within the results of terraced type, 5 storey terraced development pattern seems to be inefficient pattern because its values are so close to 2 storey development pattern. In terms of perimeter once again terraced type of building development is the most efficient development pattern but, 8 storey development has the minimum perimeter values as expected.

For creating sustainable urban development "*compact urban form*" explicitly "smart growth" as a future development concept technically analyzed with all aspect. But after that point, evaluation of new building and construction law in accordance with European Union Expert Group Report called "European Sustainable Cities"will be handled in next chapter to constitute policy options to the future developmet of Turkey.

CHAPTER 5

EUROPEAN SUSTAINABLE CITIES

Eventually it can be stated that minimizing infrastructure investment cost of public sector would be achieved by developing strategic planning decisions for all planning levels instead of including technical contributions to the physical planning process. Examinations and technical analysis that performed in previous chapters has minor contributions on general purpose. They provide technical solutions within the physical plan structure and directly require macro level strategic planning decisions and guidance. As mentioned before, proposing technical solutions to the urban infrastructure planning process provide efficient solutions to the physical planning process for the purpose of creating sustainable urban environment as well. Therefore, general structure of the future works should acknowledge European Sustainable Cities Report (1996) prepared by The Expert Group on the Urban Environment of EU as an essential reference. All defined policy options and design principles for creating future development pattern of the cities constituted the starting point of the thesis as evaluating latest "*construction and urbanization law*". Integrating all policy options that recommended by The Expert Group on the Urban Environment of EU create a well-organized structure of the physical planning process. And also provide a great contribution and guidance to the latest "*construction and urbanization law*". At that point secondary purpose of the thesis would have been achieved.

European Sustainable Cities Report has many clues and gave a direction to the study for minimizing cost of urban technical infrastructure for public sector especially in terms of urban macro form (Compact City Form) and alternative development pattern of the cities. Creating statement of objectives, an outline of required actions, and guidelines for developing a framework for action, necessary institutional conditions, and the means of implementation for future planning process will be described regarding with the report. Additionally, recent rough draft of "*construction and urbanization law*" dated 2004 is evaluated with respect to the report's policy options and strategies. Recommended policy options of the report compromise of "Sustainable Urban Management", "Sustainable Management of Natural Resources, Energy and Waste", "Sustainable Accessibility" and "Sustainable Spatial Planning". However, just Sustainable Spatial Planning, its policy options and recommendation of it have been evaluated in detail. Policy options of other sections have been given as a title, but their explanations attached to the Appendix A.

5.1. Aims and Content of the Report

The increasing urbanization of the world coupled with global issues of climate change, water shortage, environmental degradation, economic restructuring and social exclusion cause that we take a more serious consideration to the future of our cities. The European Commission Green Paper on the Urban Environment, the Treaty on European Union, the Fifth Environmental Action Programme "Towards Sustainability", the UN World Earth Summit at Rio, the series of UN conferences concluding with Habitat II, all have common themes and recommendations that lead to act directly about sustainability to the future of cities. The European Sustainable Cities Report expresses how these ideas have been developed and how they should be practiced in European urban settings. European Sustainable Cities Report handled the sustainable urban development in five sections;

- Sustainable Urban Management
- Sustainable Management of Natural Resources (Air, Water, Soil, flora and fauna Energy and Waste (Liquid waste and Solid waste)
- Socio-economic Aspects of Sustainability
- Sustainable Accessibility
- Sustainable Spatial Planning

For this study, socio-economic aspects of sustainability section were excluded during the evaluation process. Mainly, sections related urban physical planning process and built environment were studied in detail to evaluate "*construction and urbanization law*" as a new planning procedure to the existing planning process.

The Expert Group on the Urban Environment was established by the European Commission in 1991. In 1993 the Expert Group, which consists of national representatives and independent experts, launched the Sustainable Cities Project focusing on sustainable urban development and the integration of environmental objectives into planning and management strategies. The main output of the project, the European Sustainable Cities Report, is identifying the principles of sustainable development and the mechanisms needed to practice it, not only in cities, but at all levels of the urban settlement hierarchy.

In 1993, together with the European Commission, the Expert Group launched the first phase of the Sustainable Cities Project. Its principal aims are to contribute to the development of thinking about sustainability in European urban settings, to promote a wide exchange of experience, to circulate good practice about sustainability at a local level and to formulate recommendations to influence policy at European Union, Member State, regional and local level.

The contribution of the Expert Group to the Sustainable Cities Project includes two policy reports, the first published in October 1994; a good practice guide; a European Good Practice Information System on Internet; targeted summaries (for different levels of government and different sectors); and a series of broadcasting conferences. The exchange of information and experience is being further encouraged through the European Sustainable Cities and Towns Campaign, initiated at the first European Conference on Sustainable Cities and Towns (1994). The second Conference taken place in October 1996 and act as a reference point on progress on sustainability in Europe. The content of this final report represents the conclusion of discussions of the independent Expert Group on the Urban Environment.

The report has an institutional as well as an environmental focus. It is concerned with the capacity of local governments to deliver sustainability. Working towards sustainability requires a fresh look at existing policies and mechanisms and a strong set of principles on which environmentally-sound action may be based. The report provides a framework for local action and identifies a set of principles to use in setting goals and in evaluating and monitoring progress towards sustainability in urban areas:

- The principle of urban management
- The principle of policy integration
- The principle of ecosystems thinking
- The principle of cooperation and partnership

According to report, sustainable urban management should challenge the problems both caused and experienced by cities, recognizing that cities themselves provide many potential solutions, instead of shifting problems to other spatial levels or shifting them to future generations. The organizational patterns and administrative systems of municipalities should adopt the holistic approach of ecosystems thinking. Integration, cooperation and synergy are key concepts for management towards urban sustainability. Additionally, sustainable management of natural resources requires an integrated approach to closing the cycles of natural resources, energy and waste within cities. The objectives of such an approach should include minimizing consumption of natural resources, especially non-renewable and slowly renewable ones; minimizing production of waste by reusing and recycling wherever possible; minimizing pollution of air, soil and waters; and increasing the proportion of natural areas and biodiversity in cities. These objectives are easier to accomplish on a small scale. Local government therefore plays a crucial role.

For creating sustainable development, spatial planning systems are essential for the implementation of city-wide policies. Existing spatial planning systems should be strengthened by encouraging ecologically-based approaches and a move away from a narrow land use focus. The identification of environmental objectives at an early stage in the planning process, the use of targets and indicators, improved forms of public involvement in planning and the potential linkage of spatial planning. Environmental carrying capacities at local, regional and global level should be accepted as the guiding principles within which other considerations may be traded off. Achieving sustainable urban accessibility is a vital step in the overall improvement of the urban environment and maintenance of the economic viability of cities. Meeting environmental and transport objectives requires integrated approaches combining transport, environmental and spatial planning. Achieving sustainable urban accessibility requires the development of sustainability goals and indicators, target setting and monitoring, along with policies aimed at improving accessibility and not simply movement. Resolution of accessibility, economic development and environmental objectives should be the primary objective of a city's transport policy. An integrated multi-modal urban transport system is required. (EUC 1996)

This report argues that in the short term much can be achieved through practical incremental steps in the right direction - seeking to “reduce unsustainability” as much as to “achieve sustainability”.

5.2. Definitions of Sustainable Development

Developing general approach to urban sustainability, the Expert Group uses the following well-accepted definition of sustainable development;

"Sustainable development is development that meets the needs of the present

without compromising the ability of future generations to meet their own needs."(World Commission on Environment and Development 1987, p. 43).

The following definition by the World Conservation Union, UN Environment Programme and World Wide Fund for Nature (1991) is:

"Sustainable development means improving the quality of life while living within the carrying capacity of supporting ecosystems."

Sustainable development is therefore a much broader concept than environmental protection. It implies a concern for future generations and for the long-term health and integrity of the environment. It concerns for the quality of life, equity between people in the present (including the prevention of poverty), for inter-generational equity (people in the future deserve an environment which is at least as good as the one we currently enjoy), and for the social and ethical dimensions of human welfare. It also implies that further development should only take place as long as it is within the carrying capacity of natural systems. Clearly it means efficient use of natural resources and energy and minimizing waste production through the achieving daily life activities.

The following more practical and local explanation of sustainable development, provided by the International Council for Local Environmental Initiatives (1994),

"*Sustainable development is development that delivers basic environmental, social and economic services to all residents of a community without threatening the viability of the natural, built and social systems upon which the delivery of these services depends."*

This report searches the meanings of sustainability by thinking of the city in ecosystems terms. The role of cities in solving global environmental problems is acknowledged in the Green Paper on the Urban Environment. Cities affect the global system through energy and resource use, waste and polluting emissions. They affect regional systems though river catchments and flows, patterns of land use and surrounding rural areas which are subject to pollution, development and recreational pressures. The challenge of urban sustainability is to solve both the problems experienced within the cities themselves and the problems caused by cities.

UN Conference on Human Settlements Sustainable Cities Programme defined a sustainable city in 1991 as "*a city where achievements in social, economic and physical development are made to last*" even as the Habitat Agenda suggests that sustainable urban settlements should "*make efficient use of resources within the carrying capacities of ecosystems and take into account the precautionary principle approach, provide all* *people, in particular those belonging to vulnerable and disadvantaged groups, with equal opportunities for a healthy, safe and productive life in harmony with nature and cultural heritage and spiritual and cultural values, and ensure economic and social development and environmental protection thereby contributing to the achievement of national sustainable development goals.*"(UN Habitat 2002) According to report, as the numbers living in urban areas continued to increase, the achievement of global sustainable development will depend on managing the process of urban development in a sustainable manner and sustainable urbanization can not be achieved without sustainable development.

5.3. Sustainable Management of Natural Resources, Energy and Waste

The objective of this chapter is to address the problems of consumption of non-renewable or slowly renewable natural resources and energy that exceed the capacity of the natural system, and the related waste accumulation. A holistic view and an integrated approach are crucial for sustainable management of natural resources, energy and waste. For the purpose of achieving a more efficient and sustainable urban environment, identifying policy options that introduce principles of the natural systems into the management of urban systems is the main aim of this chapter.

Natural systems tend to maintain their equilibrium by circulating resources and wastes internally. In the urban system, waste is accumulated, but rather than being transformed into useful substances, it largely remains outside the circulation process. This is the major difference between the operation of the natural system and the urban system. City managers, planners, architects, builders etc. should consider the lessons that nature can teach about ecological and economical flow management.

According to Report, sustainable management should be based on the Ecosystems Approach. The Ecosystems Approach is used;

- to provide an understanding of the fundamental causes of excessive consumption of stock or flow-limited resources,

- to help focus on the policy options available for minimizing the problems and achieving more sustainable management systems.

It also emphasized the need for the integrated approach to sustainable management in terms of land-uses, activities or flows of energy in order to accomplish measures such as minimizing consumption of natural resources, increasing efficiency of energy production, utilization of renewable sources, re-use of waste and recovery of heat, and the implementation of decentralized efficient management systems.

5.3.1. Natural Resources

The presence of natural resources is fundamental to every human activity to life as a whole, both within natural systems and urban systems. Consumption of natural resources produces waste of all kinds, and creates undesirable effects on the planet's ecosystem. Apart from exceeding the capacity of the natural system, consumption is inefficient. Natural resources are consumed without regard to the balance of the natural systems. Excessive consumption is allowed to continue without an overall strategy for sustainable waste management. In other words, natural resources are extracted from the natural system to support the life of cities, but hardly anything is returned to the natural system in a useful form.

Working towards closed systems of natural resources is working towards sustainability. Currently cities are not self-sufficient closed systems; they are highly dependent on surrounding areas. Natural resources are imported into cities, consumed and then exported in the form of air pollution, water pollution and solid waste. The flows are therefore directed into cities, but instead of returning flows back to the original sources, the waste products are stored in the soil or spread to the air and water. The circulation is therefore far from complete. Working towards a closing of cycles by integrating flows into the ecological cycle and returning waste products to the original source helps to achieve a more sustainable urban environment.

5.3.1.1. Air

There can be no doubt that air, and specifically good quality and sufficient supply of air, is one of the most valuable sources for the maintenance of life on the planet.

The main goal of sustainable management in relation to air is to ensure quality and supply. As far as the objectives of sustainable management are concerned, two main issues can be identified:

- to reduce pollution sources and quantities,

- to promote the re-generation and filtering of air.

The first issue is related to production and consumption. The second issue is directly related to the protection of green features.

Energy production and consumption are the main sources of air pollution. Certainly, a large number of issues which are associated with air and its management therefore overlap with the sub-issues of energy, waste and transport in the city. According to Expert Group on Environment, several policy options summarized below available for reducing pollution sources that serve the purposes of minimizing energy consumption, increasing efficiency of energy production, utilizing renewable energy sources etc.

5.3.1.2. Water

Water is a natural resource on which all life is dependent. For humankind water is vital for basic functions (drinking, washing and cleaning), for industrial processes and for agriculture. Water is a renewable and a re-usable natural resource because rainfall is stored as groundwater and in rivers, lakes and seas, then evaporates and forms clouds which in turn result in rainfall. Problems defined by Expert Group concerning water quantity are; availability of water and polluted used water.

5.3.1.3. Soil, flora and fauna

Sustainable management should treat land as a resource for development; as a regulating factor in climate, air and water and adverse weather conditions such as flooding, frost, high winds, etc.; as a natural element which supports complex living ecosystems of flora and fauna; as a raw material source; and as a natural element. Major sources of problems are the ever-increasing need for development, a large number of activities which create various degrees of pollution (e.g. toxic waste from industry, run-off from road surface) weather erosion, the dumping of waste in liquid and solid form and activities connected with mineral extraction. As a direct result of these problems, the biotic elements for which land provides such as; flora and fauna, are also degraded. The general aim should be increasing the size of natural areas and their conservation. It is apparent that sustainable management should aim;

- the safeguarding of a necessary quantity of land for the development of natural and human-made ecosystems, green structures for the city and the surrounding areas;

- the provision of an adequate area of land for this green structure to be self-regenerative.

5.3.2. Energy

In recent years, current energy policies cause to the reduction of resources, increased pollution, and climatic effects. The adoption of the principles of sustainable development has highlighted the necessity of energy conservation, suggesting intervention at different spatial scales of planning and the use of renewable sources which are more compatible with environmental protection and conservation of natural resources. Energy is not only consumed for necessary activities and the satisfaction of needs, but it is also wasted during the production process and subsequently during both distribution and use.

In the residential, health, education, recreation, housing, services etc. consume substantial amounts of energy for the purpose of heating, lighting, ventilation and cooling of spaces. Other important energy needs have to be satisfied for the provision and functioning of infrastructure, including the lighting and maintenance of public spaces, the supply of water and the treatment of all kinds of waste. The rising need for mobility and the dependence of the city on increasingly distant areas for transportation of material goods and people has caused transportation to be another main energy consumer, especially of non-renewable fuels. This excessive energy consumption, which requires increasing external inputs of natural resources and gives rise to a growing discharge of wastes outside the urban system, causes serious internal and external environmental problems.

5.3.3. Waste

5.3.3.1 Liquid Waste

Older types of sewage networks and problems of liquid waste are the crucial problems of liquid waste. Control is needed to maximize the efficiency of Integrated

Waste Management Systems. Briefly they include water conserving measures such as recycling grey water, minimizing leakages, installing water meters, and the utilization of environmentally friendly sewerage solutions. At a broader level, what is needed today is the adoption of an integrated system of waste management.

5.3.3.2 Solid Waste

Like liquid waste, solid waste can also be divided up into categories. Domestic and commercial refuse, hospital waste, industrial by-products, reused industrial products, rubble produced by construction activities, waste that consists of mainly plastic of all kinds but particularly PVC, are the biggest problem because of their continuous accumulation. The shortage of space for waste disposal is also forced by the rapid increase in the dumping of materials that are biodegradable, but which take a long time to decompose (e.g. metals).

Incineration contributes to the greenhouse effect and releases toxic substances. Simple landfill or even sanitary burial cannot provide the answer to the problem of solid waste management. The solution to this difficult problem would appear to lie in mixed systems which advocate multiple uses, the reuse and recycling of materials in conjunction with the sanitary burial of rapidly biodegradable materials.

Sustainable waste management should include three main aims:

- reduction of waste production,
- making the best use of waste as a resource,
- avoidance of hazards to the environment and health.

The three principle of "no waste - reusable materials - recyclable materials" should be the basic ordering of priorities in waste management. Repair and reuse of goods should be emphasized.

5.4. Sustainable Accessibility

To achieve a more sustainable development cities give a high priority to the problems of mobility and access. There is broad agreement amongst policy makers from different sectors and environmental organizations on urban mobility trends by reducing reliance on the private car. It is increasingly recognized that to reverse these trends will also require a reduction in the demand for urban travel. The OECD study Urban Travel and Sustainable Development (1995) sets out three goals of an integrated policy aimed at moving towards sustainability. The first goal involves using best practice in urban policy. The second builds on the first by using innovative land-use and transport measures to reduce the need to travel and converts best practice into a coherent structured policy package. The third goal involves the application of progressive increases in fuel taxation to reduce car kilometers and CO_2 emissions, and to strengthen the other policy measures.

5.5. Sustainable Spatial Planning

Consideration of spatial planning should consider how future town and spatial planning strategies can incorporate environmental objectives. Through the European Sustainable Cities Project the Group is addressing this issue not only environmental but sustainability objectives.

5.5.1. Role of spatial planning

Spatial planning should be designed to regulate the use of land in the public interest and urban, spatial, physical or territorial planning or space management systems should be comprise two functions:

- plan-making (providing frameworks through development strategies and plans at different spatial scales from national to local);
- development control (legal or administrative procedures operating at the local level to control the location and form of development, and change of use within buildings).

Spatial planning systems are seen by the EU as one of the key mechanisms for working towards sustainable development and deal with to accommodate innovative approaches to reducing environmental damage and to improve environmental quality has increased recently.

5.5.2. Some principles of sustainable development

Many of the principles of sustainable development should be integrated into the planning systems such as;

- operating a range of spatial scales, from local to global, related to the levels at which the environmental issues arise;

- allowing community involvement, and are open and democratic in operation;

- seeking to take account of future effects and implications on different groups within the population;

- providing the opportunity to consider economic, social, and environmental objectives.

Key problems for planners are to define and measure environmental considerations and capacity for their local areas, to determine capacity constraints, to identify quantifiable indicators and to determine what kinds, what levels, and what geographical distributions of development are possible without disrupting these. These tasks require planners to work with other professionals and with local communities.

5.5.3. Policy options

- Integrating environmental and spatial planning

The relationship between spatial planning and measures to protect and enhance the physical environment, for example pollution control, varies from system to system. Urban management should be related with developing integrated environmental plans or by preparing land use plans, with or without an environmental focus.

- Environmental objectives specified at an early stage in the planning process

A general requirement for more sustainable spatial planning is that environmental objectives should be specified at an early stage in the planning process. Giving priority to environmental considerations in plan making requires analysis of the local environmental context before development plans are prepared or updated, identifying environmental assets and capacity constraints. (CEC 1996)

- Early consideration of environmental implications in the planning process

One of the means by which environmental implications can be considered earlier in the planning process is by undertaking environmental assessment of policies while development plans are being prepared. Environmental Impact Assessment can be a powerful tool for expecting the likely consequences of projects. A starting point should be to understand the interactions between objectives for the different sectors to be included within the plan. A land use objective of minimizing the consumption of space for urban development may support action in other areas such as in nature conservation. (CEC 1996)

- Integrating land use and transport planning

It is widely accepted that urban form, that is the pattern and density of development within and between settlements, influences travel patterns the ability to maintain biodiversity, and the quality of life. The spatial planning system is a key mechanism influencing urban form. The Green Paper on Urban Environment argues that the "compact city" form is likely to be the most energy efficient as well as having social and economic advantages.

- Increasing urban densities around points of high accessibility

The common feature shared by different solutions is the idea of increasing urban densities around points of high accessibility, and especially points of high accessibility to public transport. Whether this implies the maintenance of a monocentric city structure or the development of a polynuclear structure. Urban density is important because it influences the availability of mass transit provision. Empirical studies have found a strong correlation between high population density coupled with size of city and a shorter average distance traveled and also between low density and high car usage. Increasing densities related to the public transport network is the core of the Dutch long term policy to achieve "the right business in the right place", the so-called ABC system. This seeks to match the mobility needs of businesses and other activities with the accessibility characteristics of urban locations (CEC, 1996).

- The importance of vertical integration

The importance of vertical integration is demonstrated in strategic sustainability where decisions at regional level are decisive for public transport services and environmental quality to be provided at local level (CEC, 1996).

- Open space provision in land use plans

The value of open space within the urban fabric is increasingly being rediscovered. Open space comprises a variety of green spaces, including formal and informal parks, bits and pieces of natural systems, urban public spaces such as city squares and the environment around cultural monuments, and habitats which develop on disused land such as industrial sites. Spatial planning systems are the main mechanism by which these spaces remain open. Local authorities are increasingly exploring the incorporation of minimum targets for open space provision in land use plans. It is essential that all open space is viewed as part of the natural framework within which all built development rather than the "space left over after planning".

- Encourage mixed land use schemes

Over-rigid land use zoning has been criticized as one of the causes of new single use development areas within cities. By analogy to ecological systems, mono-use of land, especially over larger areas, tends to lead to deterioration, while mixed uses tend to enhance the vitality of an area. The Green Paper on the Urban Environment strongly recommends the encouragement of mixed use schemes. Mixed use is an urban form which offers the opportunity for reduction in movement overall. At the city scale it implies seeking a balance of houses, jobs and facilities in each broad sector of the city through whatever zoning or land allocation system is used. It is particularly at the neighborhood or even more local scale that mixed use can be important. Owner and user participation are critical in the planning of mixed developments. The success of mixed use schemes depends on whether the occupants use them in the way intended by planners. (CEC 1996)

5.6. Conclusions and Recommendations

The main concern of urban sustainable development that described with Expert Group is solving both the problems which are experienced within cities and the problems caused by cities. Problems should be solved locally where possible, rather than shifting them to other spatial locations or passing them on to future generations.

Similarly, recent rough draft of "construction and urbanization law" dated 2004 describes the future development plans as a plan that provide sustainable development pattern. Also it requires minimum resource consumption, energy efficiency and environmental problem solving ability in Act 8. Although its goals and objectives overlap with EU Sustainable Cities Report recommend, they are not described in detail. Moreover, used keywords related sustainability or sustainable urban development keep in limited. In order to achieve sustainable development, holistic and integrated approach to plan production process, increased priority to environmental consideration, vertical integration and cooperation between national authorities and municipalities, administrative responsibilities for plan making agencies and community involvement mentioned mainly as only planning requirements for future developments in Act 3, 6, 8, 9 and 20. Except for sustainable development requirements, only Act 20 provides an explanation about scattered development pattern and infrastructure provision relationship for the purpose of minimizing infrastructure investment cost for public sector. It is not allowed to give an accommodation authorization to the development area citizens unless technical infrastructure provision is not completed. Besides that preparing macro scale strategic plans such as; national physical plans, region and sub-region plans with their macro scale policies provide an interrelation and guidance to the micro scale plans and also provided a leveled planning system. With this system programming and timing that is provide overlapped and synchronic service provision with development stages of urban settlement areas ensured for master and development plans. To constitute a comprehensive planning system in order to achieve sustainable urban development, recent rough draft of "*construction and urbanization law*" should be supported with its by-law and regulations with respect to European Union policy options and strategies. Detailed explanations and policy options summarized below for future sustainable development pattern.

5.6.1. Sustainable urban management

An ecosystems approach to urban sustainability requires a requirement to certain patterns of organizational management that contain holistic approach for the adoption of organizational patterns and administrative systems. Urban management for sustainability is making possible through the application of these tools within city-wide policy frameworks and action plans.

In setting out the recommendations which emerge from the Sustainable Cities Project, the Expert Group is seeking to achieve:

- further integration of the economic, social and environmental dimensions of sustainability at all levels.

- improved capacity for managing urban areas for sustainability;

- greater coherence of policy and action, so that the development of sustainability at local level is not damaged by decisions and actions by governments,

- measures to avoid wasteful duplication of work and to enhance the productive exchange of experience;

- both the enhanced application of existing policies, programmes and mechanisms and, where necessary, the development of new ones. (CEC 1996)

All governmental and public agencies should:

- apply the principles and tools for policy integration;

- promote the development of sustainability evaluation in the decision making process,

- establish formal management procedures for declaring environmental aims; deciding and implementing actions towards aims; and monitoring and reporting on progress. (CEC 1996)

5.6.2. Sustainable management of natural resources, energy and waste

The Expert Group advise that an integrated approach to closing the cycles of natural resources, energy and waste should be adopted within cities. The objectives of such an approach should include minimizing consumption of natural resources, especially non-renewable and slowly renewable ones; minimizing production of waste by reusing and recycling wherever possible; minimizing pollution of air, soil and waters; and increasing the proportion of natural areas and biodiversity in cities. For this purpose policy options that summarized below should be considered in physical planning process.

- Action plan for air quality

- Greening the city

- Collecting storm water
- Facilitating the infiltration of storm water
- Facilitating the retention of storm water
- Recycling grey water
- Promoting more environmentally friendly sewerage solutions
- Controlling pollution sources
- Controlling mineral extraction
- Developing a green structure
- Restoration and enrichment of soil and flora
- Increasing bio-diversity
- Setting up city farms
- Energy conservation as a basic aim
- Introducing local energy management systems
- Promoting local energy production
- Promoting least cost planning
- Replacing non-renewable energy sources with renewable ones
- Co-generation of electricity and heat
- Recovery of industrial waste heat
- Production of energy from waste
- Using sustainable design principles
- Regular control and monitoring of waste water receptors
- Integration with other restrictive policies
- Reduction of packaging, and increased use of recyclable and reusable packaging
- Maximum separation at source
- Local composting of household and garden waste
- Regulations on use, reuse and recycling of building materials

5.6.3. Sustainable accessibility

Achieving sustainable urban accessibility is a vital step in the overall improvement of the urban environment and maintenance of the economic viability of cities. Associated environmental problems, health related problems, and social issues along with traffic-specific issues such as congestion, safety and the proportion of public space in cities engaged by transport- related activities. Environmental and transport objectives requires integrated approaches combining transport, environmental and spatial planning. Current actions towards sustainability in this field mainly seek to reduce road traffic and congestion, essentially by encouraging a modal shift from private cars to public transport and, less often, to cycling and walking.

At city level there is a need for strategic planning in the management of urban transport systems. Sustainability goals need to be developed for transport planning. Reducing demand for travel clearly requires close linkage between the management of urban transport systems and the strategic planning of future settlement patterns. As indicated above, transport and land use plans are essentially interlinked. All transport plans should be assessed within a land use framework. Policies to ensure a transfer from private to mass transit are essential. The accessibility of mass transit should be improved to take into account the needs of people with reduced mobility in particular. Policy options given below should be guidance for urban land use planning;

- Integrated multi-modal urban transport systems
    - Traffic demand management
    - Initiatives for car free city centers
    - Speed restrictions and traffic calming measures
    - High occupancy vehicles lanes can stimulate public transport and car pooling
    - Road pricing is an instrument with both advantages and disadvantages
    - Local parking policy is an important tool to control traffic volumes
    - Access restrictions on heavy goods vehicles and city distribution centers
    - Priority to public transport
    - Park and ride is widely used as a measure accompanying public transport improvements
    - A range of policy and technical initiatives are deployed to change travel behavior
    - Priority to cyclists and pedestrians
    - Cycling and walking are effective transport alternatives for short distances
    - Experimenting with specialist vehicles and fuels

CHAPTER 6

CASE STUDY: GIS AIDED EVALUATION of AYDIN DEVELOPMENT PLAN

In this chapter, Aydın future residential development area has been examined in terms of land consumption, total infrastructure length, density distribution and especially sewer system capital investment costs. Existing areas of residential regions excluded during the study, since, present ongoing and incremental costs of existing land use structure are ignored or accepted as a constant value. As a starting point, exact cost calculation of sewer system of Pilot region has been carried out. Then, detailed technical analysis of sewer system construction stages to find out which construction stages have significant importance on total investment cost during the installation process have been analyzed. Using previous comparative analysis results of "*Model Building by-law*", investigation and probable generalization on "How various development patterns that described by *"Model Building by-law"* and density decisions effect total investment cost of urban technical infrastructure?" are achieved using GIS technologies. In addition to capital cost evaluation of sewer system, various development alternatives for entire future development areas of Aydın have been evaluated in terms of land consumption and transportation network strategies. For creating sustainable urban development pattern, proposed efficient residential development patterns alternatives with their infrastructure length requirements have been compared.

6.1. General Characteristics of Study Area

Instead of performing a total calculation for all development areas of residential regions as indicated in Figure 6.1, North-east part of development zone has been selected as a pilot region for sewer system capital cost calculation. (See Figure 6.2.)

General characteristics of the study area are summarized below;

- Residential area for high-income group,
- 3 storey semi-detached building type,
- 819918, 60 m2 total area,
- 443729, 00 m2 residential area,

- 18237, 98 m total road length,

- 4359 residential units,

- 17436 people.

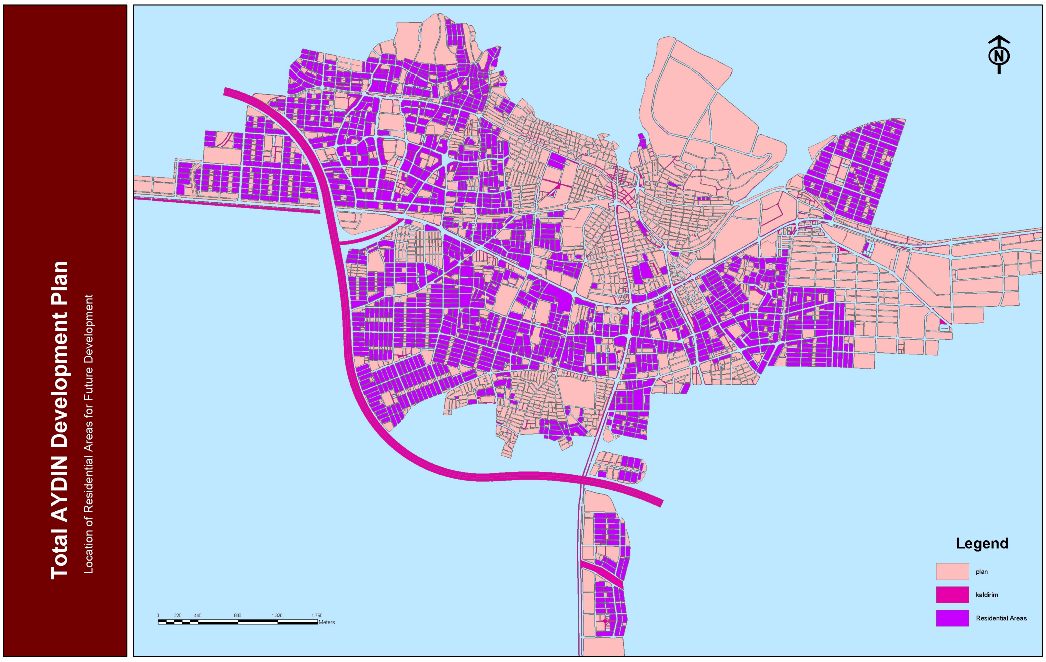


Figure 6.1. Location of Future Development Areas of Aydın Development Plan

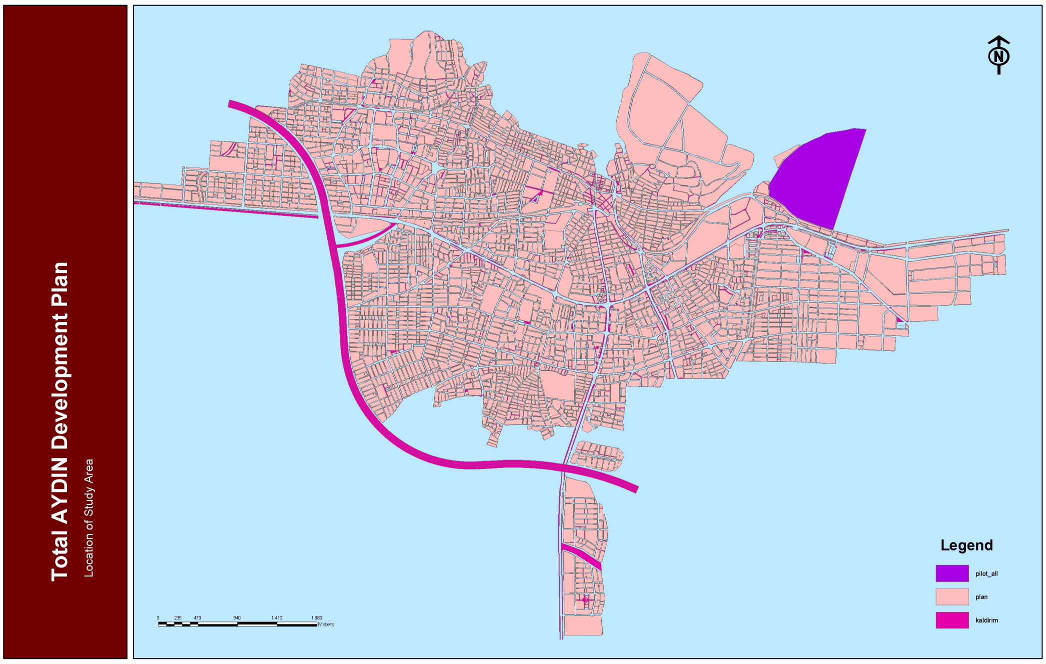


Figure 6.2. Location of Pilot Region within the Development Plan

6.2. Manhole Installation Calculation

Detailed calculation of manhole installation process of sewer system plan of the pilot region accomplished at the first place.

Sewer System Layout

Total Construction Cost Manhole Installation Calculation

Table 6.1.Calculation Table for each Task of Manhole Installation

poz no	Task	Calculation	Min.Amount	Max.Amount
14.160.040	(0-2)m Base Excavation (m3)	2,50*2,50*649.09	4056.812	4056.812
14.160.041	(2-3)m Base Excavation (m3)	2,50*2,50*60.180	376.125	376.125
14.1714/1	Trench Refill (m3)	Total amount of excavation	4432.937	
	Conic Part	329*0.5	-164.50	
	Body	428.910*1,131	-485.097	
	Base	329*0,265	-87.185	
	Pipe Volume (200mm)	658*0,65*0,0549	-23.480	3672.675
14.023/3	Retaining Support Installation (m2)	4*2,50*709.270	7092.70	
	Trench Entrance	2*0.90*709.270	-1276.68	5816.02
12.2188/1A	1 m.Body Ring Installation (m)	428.910	428.910	428.910
12.189/1A	1 m.Conic Installation (unit)	329	329	329
N.F.A.4/A	Concrete Cover Transportation	329*0,129	42.441	42.441
N.F.A..5	Prefabric Manhole Transportation			
	Conic Part	329*0,389	127.981	
	Base	329*0,389	127.981	
	Body	428.91*0,828	355.14	611.102

Calculation of Total Construction Cost

Manhole Installation

Table 6.2.Cost Calculation Table for Each Task of Manhole Installation

poz no	Task	Amount	Total Amount	Unit Price (YTL)	Total Cost (YTL)
14.160.040	(0-2) m Base Excavation (m3)		4056.812	1.76	7138.44
14.160.041	(2-3) m Base Excavation (m3)		376.125	1.83	687.00
14.1714/1	Trench Refill (m3)		3672.675	1.86	6825.79
14.023/3	İksa Installation (m2)		5816.02	4.87	28360.37
12.2188/1A	1 m Body Ring Installation		428.910	4.22	1811.54
12.189/1A	1 m Conic Installation		329	1.61	530.19
N.F.A.4A	Manhole Cover Transp.		42.441	8.58	364.10
N.F.A.5	Prefabricated Manhole Transportation		611.102	9.81	5992.88
08 1576/1	Conic Part	329		41.82	13757.10
08 1577	Top Ring	329		11.40	3747.93
08 1575/1	Body Ring	715		44.43	31764.77
08 1579/1-1	Base	329		142.15	46768.74
23 255/İB-3	Iron Grid (88kg)	28952kg		1.29	37501.90
23 255/İB-1	Manhole Cover (104kg)	34216 kg		1.47	50353.12
Total					**235603.87 YTL**

(İller Bankası Unit Cost 2002)

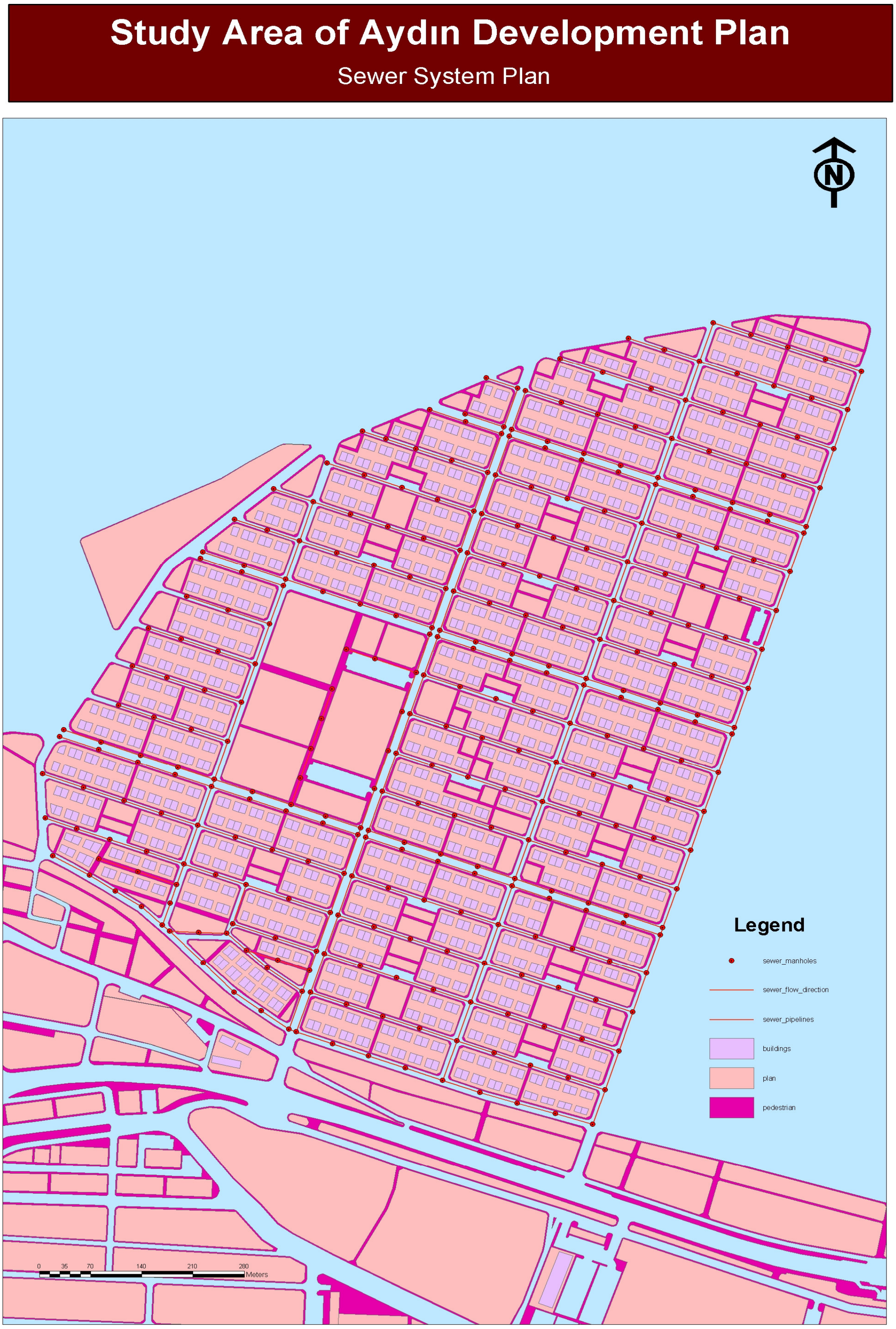


Figure 6.3.Sewer System Plan of Study area

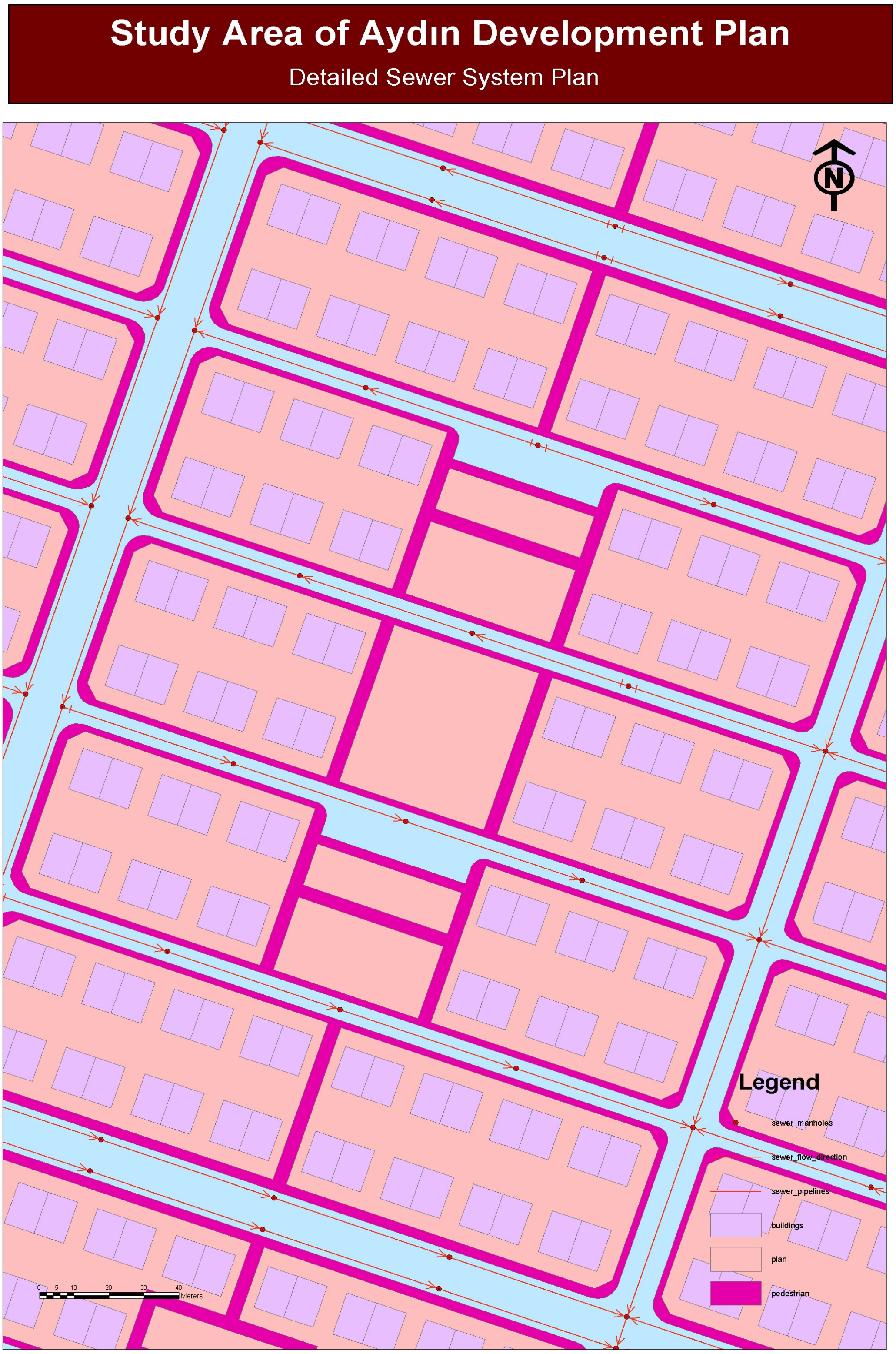


Figure 6.4. Detailed Plan of Sewer System of Study Area

6.3. Pipeline Installation Calculation for Study Area

After calculating manhole installation cost, pipeline construction cost computed.

Sewer System Plan

Calculation of Total Construction Cost

Pipeline Installation

Table 6.3.Cost Calculation Table for Each Task of Pipeline Installation

poz no	Task	Total Amount	Unit Price	Total Cost
12.218.332	200 pipe Installation (m)	19700	2,10	41410.35
1.416.003	Trench Excavation (m3)	34930.84	2.29	79839.64
14.1714/1	Trench Refill (m3)	33849.278	1.86	62910.00
14.023/3	Retaining Support (m2)	77624.091	4.88	378514.74
N.F.A.1	Concrete Pipe Transportation	1438.144	9.81	14103.41
8.157.061	Pipe Cost	19700	5.54	109229.64
TOTAL (Pipeline Installation Cost)				**686007.78**
TOTAL (Pipeline + Manhole Installation)				**921611.65**

(İller Bankası Unit Price 2002)

At the end total construction cost of manhole and pipeline is found out as 921611.65 YTL for the Study area. It means that total cost of sewer system for 3 storey semi-detached type of development is 921611.65 YTL. In other term, for 4359 units in 3 storey semi-detached type of development that has 212, 393 p/ha density of gross and net density respectively has 921611.65 YTL public investment cost for sewer system.

Using its technical analysis results and exact capital cost evaluation, total infrastructure requirements and their investment cost of residential development areas of Aydın has been calculated. With the help of table 6.5 cross comparison of infrastructure capital cost for various development patterns described with different building type and number of storey has been achieved.

6.4. Evaluation of Calculation Results of Pilot Region

Table 6.4. Evaluation of Percentage Distribution of Installation Stages

Stages of Pipeline Installation	**Unit Price (YTL)**	**%**	**Total Cost (YTL)**	**%**	**% In Total**
200 Pipe Installation (m)	2.1	7.93	41410.35	6.04	
Trench Excavation (m3)	2.29	8.65	79839.64	11.64	
Trench Backfill (m3)	1.86	7.02	62910	9.17	
İksa (m2)	4.88	18.43	378514.74	**55.18**	
Concrete Pipe Transportation	9.81	37.05	14103.41	2.06	
Pipe Cost	5.54	20.92	109229.64	**15.92**	
TOTAL (Pipeline Installation Cost)	**26.48**	**100.00**	**686007.78**	**100.00**	**74.44**
Stages of Manhole Installation	**Unit Price (YTL)**	**%**	**Total Cost (YTL)**	**%**	
(0-2) m Base Excavation (m3)	1.76	0.64	7138.44	3.03	
(2-3) m Base Excavation (m3)	1.83	0.66	687	0.29	
Trench Backfill (m3)	1.86	0.67	6825.79	2.90	
İksa Installation (m2	4.87	1.76	28360.37	**12.04**	
1 m Body Ring Installation	4.22	1.52	1811.54	0.77	
1 m Conic Installation	1.61	0.58	530.19	0.23	
Manhole Cover Transp.	8.58	3.10	364.1	0.15	
Prefabricated Manhole Transportation	9.81	3.54	5992.88	2.54	
Conic Part	41.82	15.09	13757.1	5.84	
Top Ring	11.4	4.11	3747.93	1.59	
Body Ring	44.43	16.03	31764.77	**13.48**	
Base	142.15	51.30	46768.74	**19.85**	
Iron Grid (88kg)	1.29	0.47	37501.9	**15.92**	
Manhole Cover (104kg)	1.47	0.53	50353.12	**21.37**	
TOTAL (Manhole Installation Cost)	**277.1**	**100.00**	**235603.87**	**100.00**	**25.56**
TOTAL					**921611.65**

In previous comparison between residential areas (AYKO and TORLAK), which has different type of building, it was stated that sewer system cost is significantly high amongst the other infrastructure elements costs. Capital costs of sewer systems of both study areas are approximately 66% in total cost. Therefore in order to reduce the total public investment cost of urban technical infrastructure, understanding and evaluating general structure of the sewer system is exceptionally essential. By doing that, determine in which steps of the overall process of installation has great importance for future development decisions.

Eventually, evaluating the results of the installation cost elements of sewer system, it can be stated that pipeline installation cost is three times higher than manhole installation. Pipeline and manhole installation costs are 74% and 26% respectively. So compared to overall installation process, it is recommended that reducing pipeline construction cost decrease the total cost considerably. Within the pipeline construction process, trench excavation, retaining support installation and pipe cost have the highest rate in total cost distribution. But retaining support installation has the highest rate of 55.18% of total. Therefore location of settlement and solidity of soil has direct effect on total construction cost. Retaining support installation is carried out just for creating safer working conditions for workers and materials during the construction process. That's why location conditions of site are crucial effect on construction cost of sewer system. Additionally, reducing total length of pipeline decreases pipeline construction cost 16% and 11.8% of overall construction cost. In terms of manhole installation, surprisingly trench excavation for manhole is not significant contributor on installation costs. Number of manhole and depth of manhole are very important factors for reducing construction cost, because their effects are approximately 13.48% of depth of manhole and 16 to 21% of number of manhole that contain base, cover and grid iron parts. Prepared table for various types of buildings that contain area, perimeter, road length and road coverage area figures for 2800 unit neighborhood can be used to calculate amount of infrastructure for different type and storey building that described with "*Model Building by-law*" of residential areas. Using calculated value for 3 storey semi-detached building type, it can be calculated sewer system construction cost of other type of buildings. For example using 921611, 65 YTL construction cost that calculated for the study area, it can be calculated the value of 2 storey detached type of building as; 921611, 65 / 0.757 = 1217452, 64 YTL (3 storey detached type and 1217452, 64 / 0.687 = 1772129, 02 YTL (2 storey detached type of building). (See Table 6.5)

Table 6.5. Comparison Between Conventional Rectangular Building Blocks and Proposed One for 2800 Units

	DETACHED (dublex or triplex)						DETACHED					Decr.Rate Based to Detached	SEMI-DETACHED					Decr.Rate Based to Detached	TERRACED					Decr.Rate Based to Detached	APARTMENT BLOCK					Decr.Rate Based to Detached	
2 Storey	Area (m2)	848148,00					424074,00					0,500	318136,00					0,750	231472,00					0,546	252770,00					0,596	Area (m2)
	848148,00	Perimeter (m)	3776,00					2750,00				0,728		2474,00				0,900		2158,00				0,785		2214,00				0,805	Perimeter (m)
		3776,00	TRL (m)	30824,00					15794,00			0,512			12012,00			0,761			8950,00			0,567			9720,00			0,615	TRL (m)
			30824,00	TRCA (m2)	202552,00					100933,00		0,498				75425,00		0,747				55097,00		0,546				60291,00		0,597	TRCA (m2)
				202552,00	Infrastructure Length (m)	30824,00					15794,00	0,512					12012,00	0,761					8950,00	0,567					9720,00	0,615	Infrastructure Length
					30824,00																										
Proposed 2 Storey	Area (m2)	954144,39					477083,25					0,500	357903,00					0,750	260406,00					0,546	286177,25					0,600	Area (m2)
	954144,39	Perimeter (m)	3971,50					2876,50				0,724		2566,00				0,892		2250,00				0,782		2304,50				0,801	Perimeter (m)
		3971,50	TRL (m)	32266,82					16530,00			0,512			12564,00			0,760			9364,00			0,566			10204,75			0,617	TRL (m)
			32266,82	TRCA (m2)	211967,49					105642,25		0,498				78967,00		0,747				57673,00		0,546				63360,00		0,600	TRCA (m2)
				211967,49	Infrastructure Length	30246,94					15020,00	0,497					10896,50	0,725					8125,75	0,541					9388,75	0,625	Infrastructure Length
					30246,94																										
Increase rate	1,125	1,052	1,047	1,046	0,981		1,125	1,046	1,047	1,047	0,951		1,125	1,037	1,046	1,047	0,907		1,125	1,043	1,046	1,047	0,908		1,132	1,041	1,050	1,051	0,966		
3 Storey	Area (m2)	848148,00					282900,00					0,334	212474,00					0,751	154606,00					0,547	168912,00					0,597	Area (m2)
	848148,00	Perimeter (m)	3776,00				0,667	2474,00				0,655		2000,00				0,808		1750,00				0,707		1743,00				0,161	Perimeter (m)
		3776,00	TRL (m)	30824,00				0,900	10856,00			0,352			8221,00			0,757			6130,00			0,565			6596,00			0,608	TRL (m)
			30824,00	TRCA (m2)	202552,00				0,687	67333,00		0,332				50547,00		0,751				36785,00		0,546				40071,50		0,595	TRCA (m2)
				202552,00	Infrastructure Length	30824,00				0,667	10856,00	0,352					8221,00	0,757					6130,00	0,565					6596,00	0,608	Infrastructure Length
					30824,00						0,687																				
Proposed 3 Storey	Area (m2)	954144,39					318262,50					0,334	239033,25					0,751	173931,75					0,547	191216,25					0,601	Area (m2)
	954144,39	Perimeter (m)	3971,5				0,667	2566,00				0,646		2092,00				0,815		1830,50				0,713		1830,50				0,713	Perimeter (m)
		3971,5	TRL (m)	32266,82				0,892	13350,50			0,414			8606,25			0,645			6417,50			0,481			6930,50			0,519	TRL (m)
			32266,82	TRCA (m2)	211967,00				0,808	70472,50		0,332				52921,75		0,751				38515,75		0,547				42106,75		0,597	TRCA (m2)
				211967,00	Infrastructure Length	30246,94				0,667	9871,75	0,326					7536,50	0,763					5433,75	0,550					5871,25	0,595	Infrastructure Length
					30246,94						0,657																				
Increase rate	1,125	1,052	1,047	1,046	0,981		1,125	1,037	1,230	1,047	0,909		1,125	1,046	1,047	1,047	0,917		1,125	1,046	1,047	1,047	0,886		1,132	1,050	1,051	1,051	0,890		
4 Storey	Area (m2)						245165,75						183752,00					0,750	133694,00					0,545	134003,00					0,547	Area (m2)
		Perimeter (m)					0,578	2068,00						1862,00				0,900		1656,00				0,801		1656,00				0,801	Perimeter (m)
			TRL (m)					0,752	8681,00						6641,00			0,765			4948,50			0,570			4954,50			0,571	TRL (m)
				TRCA (m2)					0,550	72646,50						54245,00		0,747				39144,75		0,539				39201,75		0,540	TRCA (m2)
					Infrastructure Length					0,720	8681,00						6641,00	0,765					4948,50	0,570					4954,50	0,571	Infrastructure Length
											0,550																				
Proposed 4 Storey	Area (m2)						272538,62						204268,00					0,750	148621,00					0,545	148964,50					0,547	Area (m2)
		Perimeter (m)					0,571	2171,50						1942,50				0,895		1713,50				0,789		1713,50				0,789	Perimeter (m)
			TRL (m)					0,755	9072,00						6934,75			0,764			5161,25			0,569			5167,25			0,570	TRL (m)
				TRCA (m2)					0,549	75869,37						56653,25		0,747				40892,75		0,539				40949,75		0,540	TRCA (m2)
					Infrastructure Length					0,718	7976,50						5863,12	0,735					4041,87	0,507					4047,87	0,507	Infrastructure Length
											0,531																				
Increase rate							1,112	1,050	1,045	1,044	0,919		1,112	1,043	1,044	1,044	0,883		1,112	1,035	1,043	1,045	0,817		1,112	1,035	1,043	1,045	0,817		
5 Storey	Area (m2)						303240,00						231648,00					0,764	186960,00					0,617	212895,00					0,702	Area (m2)
		Perimeter (m)					0,715	2318,00						2310,00				0,997		2096,00				0,904		2170,00				0,936	Perimeter (m)
			TRL (m)					0,843	10284,00						7670,00			0,746			6464,00			0,629			7271,00			0,707	TRL (m)
				TRCA (m2)					0,651	109560,00						78180,00		0,714				64992,00		0,593				74232,00		0,678	TRCA (m2)
					Infrastructure Length					1,085	10284,00						7670,00	0,746					6464,00	0,629					7271,00	0,707	Infrastructure Length
											0,651																				
Proposed 5 Storey	Area (m2)						333830,00						255016,00					0,764	205820,00					0,617	234371,25					0,702	Area (m2)
		Perimeter (m)					0,700	2398,50						2367,50				0,987		2142,00				0,893		2227,50				0,929	Perimeter (m)
			TRL (m)					0,834	10731,75						7969,00			0,743			6717,00			0,626			7570,00			0,705	TRL (m)
				TRCA (m2)					0,649	114390,00						81423,00		0,712				67752,00		0,592				77475,00		0,677	TRCA (m2)
					Infrastructure Length					1,083	9377,50						6836,00	0,729					5302,75	0,565					5948,75	0,634	Infrastructure Length
											0,624																				
Increase rate							1,101	1,035	1,044	1,044	0,912		1,101	1,025	1,039	1,041	0,891		1,101	1,022	1,039	1,042	0,820		1,101	1,026	1,041	1,044	0,818		
6 Storey	Area (m2)						296718,75						247156,25					0,833	179437,50					0,605	205671,87					0,693	Area (m2)
		Perimeter (m)					0,700	2280,00						2058,00				0,903		1822,00				0,799		1933,00				0,848	Perimeter (m)
			TRL (m)					0,829	9249,50						7680,00			0,830			5689,00			0,615			6351,50			0,687	TRL (m)
				TRCA (m2)					0,586	117587,75						96439,50		0,820				69281,00		0,589				78082,50		0,664	TRCA (m2)
					Infrastructure Length					1,165	9249,50						7680,00	0,830					5689,00	0,615					6351,50	0,687	Infrastructure Length
											0,586																				
Proposed 6 Storey	Area (m2)						324016,87						266686,87					0,823	195945,75					0,605	224917,87					0,694	Area (m2)
		Perimeter (m)					0,679	2383,50						2124,50				0,891		1879,50				0,789		2002,00				0,840	Perimeter (m)
			TRL (m)					0,829	9682,75						7945,50			0,821			5913,75			0,611			6755,25			0,698	TRL (m)
				TRCA (m2)					0,586	123119,50						99807,12		0,811				72123,00		0,586				83436,62		0,678	TRCA (m2)
					Infrastructure Length					1,165	8522,12						6697,25	0,786					4624,62	0,543					5526,87	0,649	Infrastructure Length
											0,567																				
Increase rate							1,092	1,045	1,047	1,047	0,921		1,079	1,032	1,035	1,035	0,872		1,092	1,032	1,040	1,041	0,813		1,094	1,036	1,064	1,069	0,870		
7 Storey	Area (m2)						302600,00						242080,00					0,800	170479,50					0,563	198981,75					0,658	Area (m2)
		Perimeter (m)					0,714	2334,00						2062,00				0,883		1913,50				0,820		1913,50				0,820	Perimeter (m)
			TRL (m)					0,849	8796,00						7056,00			0,802			5284,00			0,601			5966,00			0,678	TRL (m)
				TRCA (m2)					0,557	129693,00						102425,00		0,790				73563,25		0,567				85157,25		0,657	TRCA (m2)
					Infrastructure Length					1,285	8796,00						7056,00	0,802					5284,00	0,601					5966,00	0,678	Infrastructure Length
											0,557																				
Proposed 7 Storey	Area (m2)						328187,50						262550,00					0,800	188357,50					0,574	221176,25					0,674	Area (m2)
		Perimeter (m)					0,688	2426,00						2131,00				0,878		1983,50				0,818		1983,50				0,818	Perimeter (m)
			TRL (m)					0,843	9129,50						7320,50			0,802			5514,50			0,604			6243,25			0,684	TRL (m)
				TRCA (m2)					0,552	134580,50						106335,00		0,790				76886,75		0,571				89275,50		0,663	TRCA (m2)
					Infrastructure Length					1,274	7910,75						5988,25	0,757					4295,75	0,543					4882,62	0,617	Infrastructure Length
											0,527																				
Increase rate							1,085	1,039	1,038	1,038	0,899		1,085	1,033	1,037	1,038	0,849		1,105	1,037	1,044	1,045	0,813		1,112	1,037	1,046	1,048	0,818		
8 Storey	Area (m2)						307450,00						243101,00					0,791	169968,00					0,553	198687,50					0,646	Area (m2)
		Perimeter (m)					0,725	2366,00						2058,00				0,870		1883,00				0,796		2031,50				0,859	Perimeter (m)
			TRL (m)					0,860	8343,00						6714,00			0,805			4857,00			0,582			5673,50			0,680	TRL (m)
				TRCA (m2)					0,528	139620,00						110857,50		0,794				76352,25		0,547				90826,12		0,651	TRCA (m2)
					Infrastructure Length					1,383	8343,00						6714,00	0,805					4857,00	0,582					5673,50	0,680	Infrastructure Length
											0,528																				
Proposed 8 Storey	Area (m2)						331502,75						262119,37					0,791	183265,62					0,553	217937,50					0,657	Area (m2)
		Perimeter (m)					0,695	2446,50						2115,50				0,865		1929,00				0,788		2101,50				0,859	Perimeter (m)
			TRL (m)					0,851	8639,75						6944,00			0,804			5024,25			0,582			5963,75			0,690	TRL (m)
				TRCA (m2)					0,523	144621,75						114781,87		0,794				79165,12		0,547				95803,50		0,662	TRCA (m2)
					Infrastructure Length					1,369	7306,12						5746	0,786					3651,87	0,500					4644,12	0,636	Infrastructure Length
											0,486																				
Increase rate							1,078	1,034	1,036	1,036	0,876		1,078	1,028	1,034	1,035	0,856		1,078	1,024	1,034	1,037	0,752		1,097	1,034	1,051	1,055	0,819		

6.5. Evaluation of Total Development Area of AYDIN

After analyzing sewer system construction stages of pilot region, total development areas of Aydın is examined with respect to general distribution rates of number of storey, type of building, net density and transportation network structure. But existing residential areas and their spatial values are excluded from the total data of Aydın. During the examination stages, general structure of Aydın development plan is evaluated to find out whether it is sustainable development or not.

Aydın total development area is calculated as a 2652.06 ha. Total urban block area is 1798.98 ha and total residential urban block area is 691.97 ha. Total transportation network around the residential urban blocks is 298549.83 m. At first stage, general percentage distribution of number of storey and building type of all buildings to be located in the future development areas of Aydın are evaluated. (See Table 6.6 and 6.7) According to total plot area percentage distribution of residential development area, 49.38%, 20.64% and 19.25% of total plot area developed as 3, 4, and 5 storey residential building area respectively. It means approximately half of total development area constructed as 3 storey and 45.61% of total population accommodate in these areas. Other number of storey percentage distribution figures (1, 2, 6, 7, 8 and 9 storey) represents 10.73% and 11.68% of population accommodate in these areas in total. Additionally, 37.03% of total plot area and 43.67% of total population living in semi-detached type building areas. 4 Storey and terraced type of development, which accepted the most efficient type of development, has just 20.63% and 17.23% of land consumption values respectively. Although high storey, terraced and block type of buildings are located along with the main transportation routes and adjacent areas of existing development areas, 2, 3 storey semi-detached and detached type of development pattern consume great amount of space in the perimeter areas. With respect to sustainable development strategies Aydın development plan represent unsustainable urban development in terms of land consumption.

With the help of table 6.5, Instead of 3 storey semi-detached type development would be constructed as 4 storey terraced type of building, used 378.21 ha development area decrease to 158.64 ha. Thus, 219. 56 ha development area would be saved and it means 28.66% in total. What if total residential area (691.97 ha) is developed as 4 storey terraced type residential area? In that case, using Table 4.29, total development area would decrease to 257.68 ha from 691.97 ha and in represent 37.7% of decrease.

Table 6.6 Number of Storey Analysis of Development Plan of Aydın

Type of Building Analysis for Residential Development Area	**Total Plot Area (ha)**	**%**	**Population (pe)**	**%**	**Number of Units**	**%**	**Total Floor Area (ha)**	**Average (FAR)**
1 Storey	1,36	0,18	168	0,05	42	0,05	0,44	0,32
2 Storey	28,46	3,72	7300	2,22	1825	2,21	20,6	0,72
3 Storey	378,21	49,38	149759	45,61	37721	45,76	480,28	1,27
4 Storey	158,1	20,64	67036	20,42	16748	20,32	195,28	1,24
5 Storey	147,46	19,25	73176	22,29	18299	22,20	239,92	1,63
6 Storey	22,52	2,94	12344	3,76	3078	3,73	37,45	1,66
7 Storey	15,56	2,03	6898	2,10	1673	2,03	20,04	1,29
8 Storey	10,57	1,38	8080	2,46	2160	2,62	24,09	2,28
9 Storey	3,68	0,48	3564	1,09	891	1,08	9,34	2,54
	765,92	100,00	**328325**	100,00	**82437**	100,00	**1027,44**	**1,34**

Table 6.7 Type of Building Analysis of Development Plan of Aydın

Type of Building Analysis for Residential Development Area	**Total Plot Area (ha)**	**%**	**Population (pe)**	**%**	**Number of Units**	**%**	**Total Floor Area (ha)**	**Average (FAR)**
Detached Type of Buildings	205,77	26,86	65318	19,90	16466	19,97	236,17	1,15
Semi-Detached Type of Buildings	283,64	37,03	143375	43,67	36110	43,80	422,01	1,49
Terraced Type of Buildings	131,97	17,23	45796	13,95	11456	13,90	134,22	1,02
Block Type of Buildings	144,65	18,88	73806	22,48	18405	22,33	235,04	1,62
	766,03	100,00	**328295**	100,00	**82437**	100,00	**1027,44**	**1,34**

In the case of orderly placement of service utilities in transverse road line and along with the transportation routes, total length of transportation routes directly effect the total capital cost of urban technical infrastructure investment. For reducing it, shorting total length of transportation routes by using of different building type and number of storey decisions for residential development areas had been proposed in chapter 3. In Table 6.8 and 6.9, evaluation of total transportation network analysis for residential development areas with different number of storey and different type of buildings performed. In general evaluation, 51.47% and 39.69% of total transportation network constructed for 3 storey and semi-detached type of residential development respectively again.19.16% and 18.11% of total length of transportation routes constructed for 4 and 5 storey residential areas respectively and the others have 11.26% in total. Similar to land consumption figures, terraced type of development has the least values of 16.60% in total. If 3 storey semi-detached development area developed as 4 storey terraced type residential development, existing infrastructure length decreased to 91918.95 m from 178286.76 m. decreased rate is 51.55%. 86367.81 m infrastructure length would be saved. As a real capital cost it means 4040486.28 YTL saving.

Table 6.8 Transportation Network Analysis for Different Number of Storey

Transportation Network Analysis for Residential Development Areas with Different Number of Storey	**Total Length (m)**	**%**
1 Storey	587,48	0,17
2 Storey	10260,02	2,96
3 Storey	178286,76	51,47
4 Storey	66367,29	19,16
5 Storey	62741,66	18,11
6 Storey	13197,38	3,81
7 Storey	7484,63	2,16
8 Storey	4566,88	1,32
9 Storey	2900,09	0,84
Total	**346392,19**	**100,00**

Table 6.9 Transportation Network Analysis for Different Building Type

Transportation Network Analysis for Residential Development Areas with Different Building Type	**Total Length (m)**	**%**
Detached Type of Building	93642,04	21,85
Semi-Detached Type of Building	170073,33	39,69
Terraced Type of Building	71119,99	16,60
Block Type of Building	93642,04	21,85
	428477,4	**100,00**

Table 6.10 Net Density Analysis for Total Development Area

Net Density Analysis for Residential Development Area	Area (ha)	%	Population	%	Number of Building Block	%
18-278 pe/ha	81,96	11,85	12818	3,90	143	9,33
279-464 pe/ha	297,52	43,00	117050	35,65	680	44,36
465-660 pe/ha	208,86	30,19	111490	33,96	448	29,22
661-982 pe/ha	89,74	12,97	70315	21,42	229	14,94
983-1694 pe/ha	13,79	1,99	16620	5,06	33	2,15
Total	**691,87**	**100,00**	**328293**	**100,00**	**1533**	**100,00**

Calculated net density for pilot region is 393 pe/ha. Using GIS technologies future residential development areas has been categorized according to their net density values. Program calculated 5 net-density categories at natural break points. In general, Aydın development plan for residential areas design with mainly 279-464 and 465-660 pe/ha. This figure represents 2 and 3 storey and detached, semi-detached type of development. It means 73.19% of total development areas (calculated as 506.38 ha) developed as low density residential areas. In addition 69.61% of total population accommodates in these areas. This type of development pattern is located in peripheral areas of existing residential areas. Just 14.96% of total residential areas developed as high density areas. Therefore this type of net-density distribution causes a great amount of land consumption and increased length of infrastructure. As Table 6.11 indicates that development pattern of detached type modified to semi-detached, terraced and block type development net-density rates increase between 1.26-1.34, 1.62-1.80 and 1.43-1.67 respectively. Surprisingly 4 storey and terraced type of development has a maximum increase rate of net density among the other type of development patterns. After all statistical analysis; this type of development pattern seems inefficient. It means existing development pattern is not sustainable in terms of energy, waste and natural resource allocation. To achieve "*compact urban form*" residential urban development areas should be designed with 754-838 pe/ha of net density which is created by 4 storey terraced type of development pattern. If low density development areas (506.38 ha) design with 838 pe/ha of 4 storey terraced type of development, 510963 person would be accommodated within the same area or If low density development areas that accommodates 228540 people developed with 838 pe/ha of net density, 272 ha development area would be required. And this figures represents 233 ha land saving.

Table 6.11 Net Density Comparison Table for Single Building Block with Different Type of Building and Number of Storey

	Detached Type of Building (Dublex or Triplex) Net Density (pe/ha)	Detached Type of Building Net Density (pe/ha)	Semi-Detached Type of Building Net Density (pe/ha)	Incr.Rate Based to Detached	Terraced Type of Building Net Density (pe/ha)	Incr.Rate Based to Detached	Block Type of Building Net Density (pe/ha)	Incr.Rate Based to Detached
2 Storey	132	264	352	**1,33**	484	**1,83**	440	**1,67**
Proposed 2 Storey	117	234	313	**1,34**	430	**1,84**	391	**1,67**
Decrease rate	**0,89**	**0,89**	**0,89**		**0,89**		**0,89**	
3 Storey	132	396	528	**1,33**	726	**1,83**	660	**1,67**
Proposed 3 Storey	117	352	469	**1,33**	645	**1,83**	587	**1,67**
Decrease rate	**0,89**	**0,89**	**0,89**		**0,89**		**0,89**	
4 Storey		457	609	**1,33**	838	**1,83**	762	**1,67**
Proposed 4 Storey		411	548	**1,33**	754	**1,83**	685	**1,67**
Decrease rate		**0,90**	**0,90**		**0,90**		**0,90**	
5 Storey		369	483	**1,31**	599	**1,62**	526	**1,43**
Proposed 5 Storey		335	443	**1,32**	544	**1,62**	478	**1,43**
Decrease rate		**0,91**	**0,92**		**0,91**		**0,91**	
6 Storey		372	459	**1,23**	628	**1,69**	545	**1,47**
Proposed 6 Storey		341	421	**1,23**	575	**1,69**	499	**1,46**
Decrease rate		**0,92**	**0,92**		**0,92**		**0,92**	
7 Storey		370	462	**1,25**	647	**1,75**	555	**1,50**
Proposed 7 Storey		341	426	**1,25**	597	**1,75**	511	**1,50**
Decrease rate		**0,92**	**0,92**		**0,92**		**0,92**	
8 Storey		364	460	**1,26**	659	**1,81**	558	**1,53**
Proposed 8 Storey		338	427	**1,26**	611	**1,81**	518	**1,53**
Decrease rate		**0,93**	**0,93**		**0,93**		**0,93**	

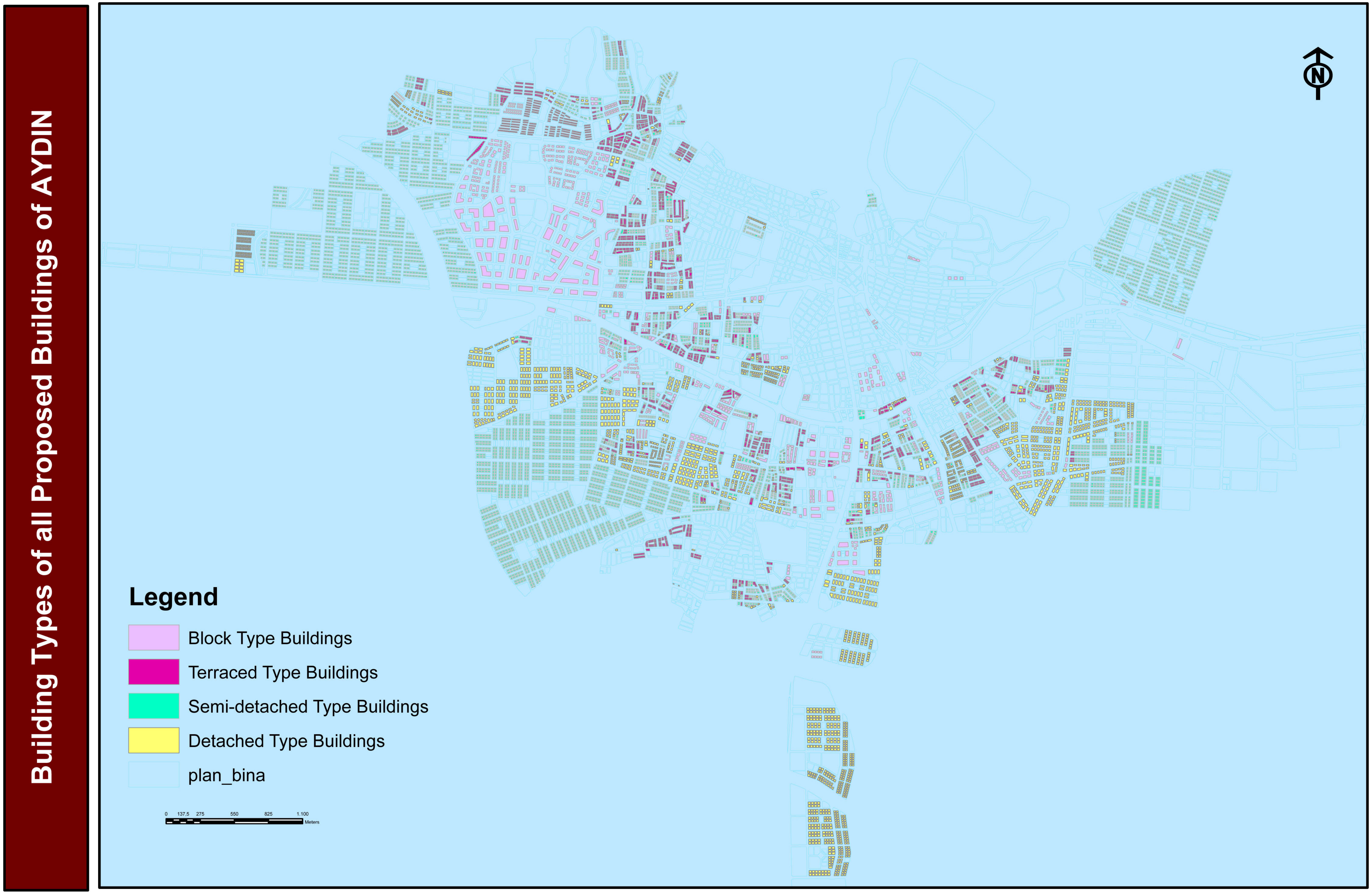


Figure 6.5 Building Types Distribution of Development Area of Aydın

Figure 6.6 Number of storey Distribution of Development Area of Aydın

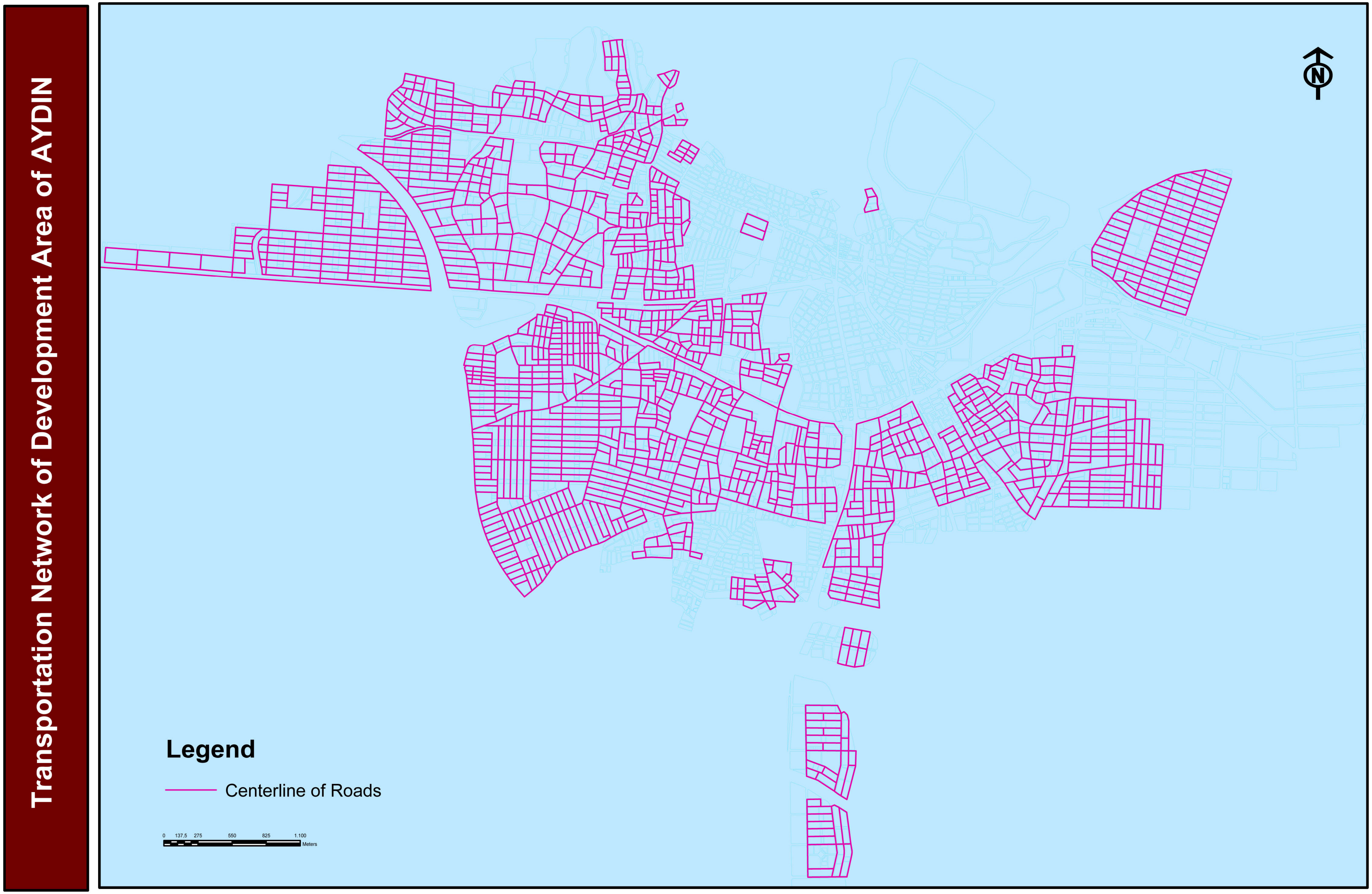


Figure 6.7 Total Transportation Network of Development Area of Aydın

Net Density Distribution of Development Areas of AYDIN

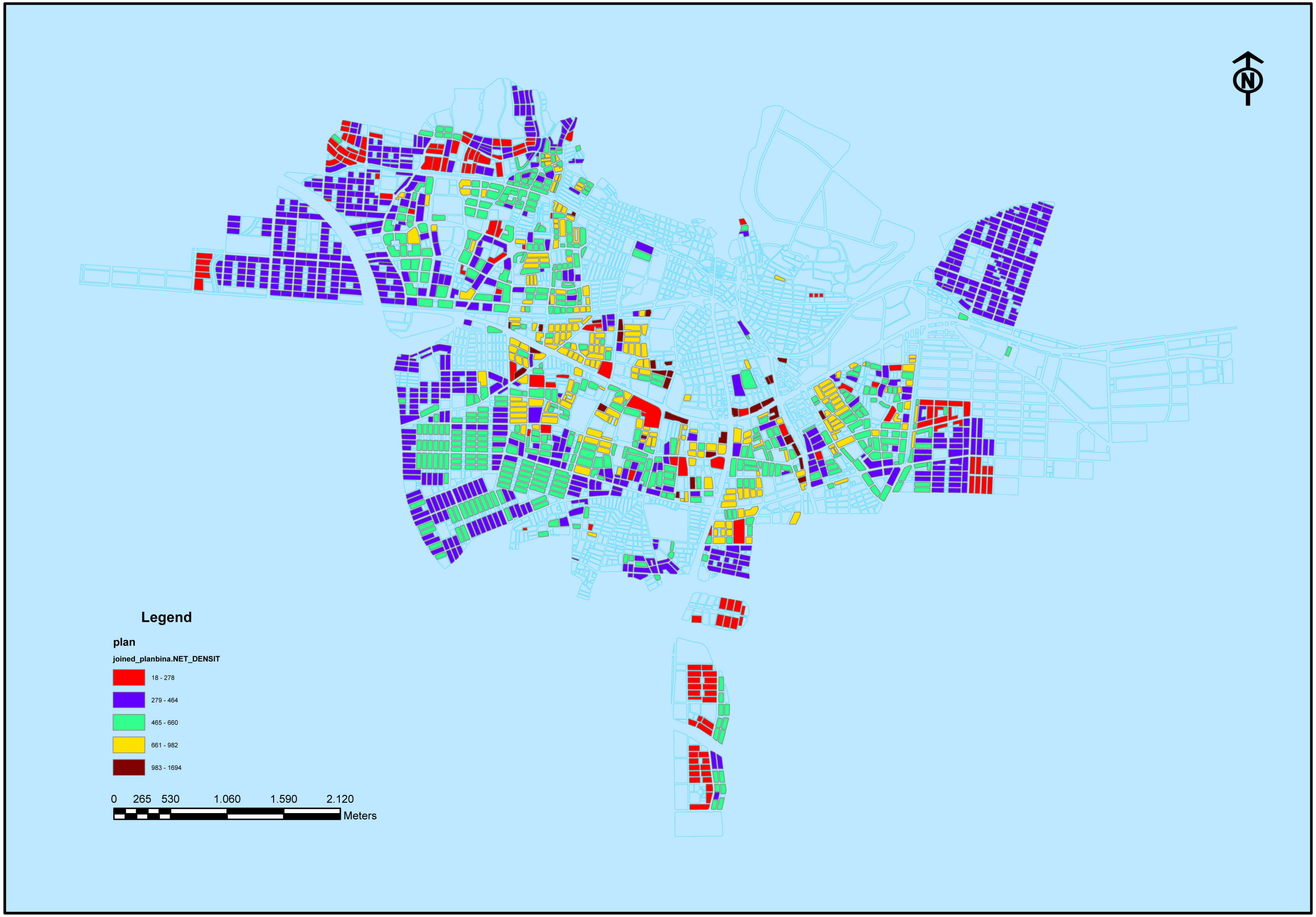


Figure 6.8 Net Density Distribution of Development Area of Aydın

CHAPTER 7

CONCLUSION

In previous chapters it was emphasized that main concentration of the study is minimizing total urban technical infrastructure public investment costs in order to create sustainable urban development. Within the entire structure of the service utilities that described and classified as; macro-scale supporting elements; distribution elements within the settlement and removal elements of waste, network structure of infrastructure provision is major concern of the study. It is so clear that total investment cost for public sector principally depends on urban macro-form alternatives that are created by general land use decisions, circulation network for vehicles and pedestrians and density decisions. Therefore, during the study, macro-scale substantive and procedural approaches related with urban 3D structure and plan production process of both (infrastructure and urban planning) and micro-scale substantive contributions related technical construction alternatives constituted the main body of the thesis. It is realized that providing consolidated and integrated management system for each institutional and organizational structure of the different service providers would reduce total capital and incremental cost of public sector. For that reason integrated plan production process that provide an improvement for planning and control system using strategic planning tools, increased efficiency and integration of sectoral policies will be described as a further study for next level of the study.

Number of storey decisions and type of buildings that has been described by the "*Model building by-law (Tip İmar Yönetmeliği)"* define the size and macro-form of the urban settlements. Size and intensive land use pattern of the city have direct relation with service costs. Traditional planning practice has required space for urban technical infrastructure under urban traffic routes. It means that infrastructure construction cost is directly related with total roadway length and size of the settlement. For reducing public investment cost of infrastructure, reducing total amount of road length and searching for alternative location for service utilities within the urban settlement seems to be possible solution.

Alternative location for service utilities could be under the centerline of the building block. In general, all infrastructure elements tend to locate under the sidewalks except for storm water and sewer system. If sidewalk width is minimum 10.00 m, sewerage pipes can be located under the sidewalks. But for reducing urban technical infrastructure investment cost, alternative location for certain types of infrastructure elements should be considered for future urban development patterns. For this purpose, alternative building block which requires a public space (5.75 m in width) in the centerline of the building block could be designed. Except for main water and gas pipelines, all infrastructure elements could be taken a place in the backyard of each parcel. Compared to traditional rectangular building block dimensions, proposed building block dimensions increased 10.6%, 4.5% and 3.5% in terms of building block's coverage area, perimeter and total road length respectively. For larger area which consists of 2800 dwelling unit of neighborhood examined with respect to their total road length and infrastructure length. At this point it is realized that total road length increase average 4.9% but infrastructure length decrease 13.4%. For 2800 unit residential area, according to "*model building by-law*" regulations, 9.30 m road width refers four storey development types. Up to this road width (provided that roadways are used for infrastructure location), infrastructure length decrease rate for 2800 units is just 13.4% for proposed building block type, because every infrastructure elements are located once under roadways and sidewalks. However, for 5,6,7,8 storey that decrease rate means 113.4% because all infrastructure elements are located once in 5.75 m width public space instead of locate under roadways for both side. Moreover, his type of development has many advantages;

- Reduced stress on public vehicular roads and sidewalk,
- Reduced maintenance and repair cost,
- Reduced infrastructure investment cost,
- Reduced social cost,
- 2.75 m and narrower sidewalks become suitable area for vegetation elements.
- Usage of roadways turns in to just for moving public good and circulation channels.

Except for alternative location of service utilities within the urban layout, reducing total amount of road length by means of compact land use pattern using underground space and multi-layered land use structure and hexagonal development pattern are alternative solutions for minimizing infrastructure public investment cost. Shorting the road length could only be possible by developing alternative development patterns using different building types and number of storey decisions that has been described by Turkish "*model building by-law*". Various development patterns statistically compared with respect to their land consumption and total road length. In terms of land consumption, total road length and total infrastructure length, 2 storey detached type of development has max values. But, 4 storey surprisingly indicate more efficient values amongst the all building types and number of storey decisions. 4 storey terraced type development has maximum amount of land saving. In the case study of Aydın it is demonstrated that if 3 storey semi-detached type development would be constructed as 4 storey terraced type of building, used 378.21 ha development area decrease to 158.64 ha. Thus, 219. 56 ha development area would be saved and it means 28.66% in total. What if total residential area (691.97 ha) would be developed as 4 storey terraced type residential area? In that case total development area would decrease to 257.68 ha from 691.97 ha and in represent 37.7% of decrease of land consumption. Moreover, evaluation of total transportation network analysis of Aydın indicate that if 3 storey semi-detached type development area developed as 4 storey terraced type, existing infrastructure length decreased to 91918.95 m from 178286.76 m. decreased rate is 51.55%. 86367.81 m infrastructure length would be saved. As a real capital cost it means 4040486.28 YTL saving.

Converting the rectangular conventional shape of residential building block to hexagonal provides 8% decrease in terms of perimeter of building block. That figure means 8% of reduced total road length and also infrastructure investment cost. Although hexagonal development patterns has many advantages like summarized previous section, the critics generally focus on inappropriate orientation and navigation, uncomfortable driving for drivers and odd lots shape. However, all considered drawbacks can be healed by urban design implementation strategies and principles. For this reason new urban development pattern for future development can be described as superimposed pattern of hexagonal and gridiron development pattern. All critics about hexagonal pattern can be resolved by integrating transportation and orientation abilities of gridiron layout of urban structure. While traffic routes of hexagonal pattern will be used for lateral traffic routes, pedestrian routes and location place of all infrastructure elements within the proposed pattern, main transportation routes will be used on gridiron pattern. It means transportation and infrastructure network structure, can be design separately. By doing this, general stress on transportation network, used as circulation area for services and goods, would be shared by both network areas. On the contrary, if infrastructure elements are located under the centerline of building blocks, total infrastructure length starts to increase % 10.1 surprisingly. For such kind of solution, (if infrastructure elements are not located under roadways) hexagonal development pattern is not economic and efficient applications in terms of infrastructure investment cost. So, hexagonal development pattern can be applied just for the location of infrastructure elements under the roadways.

In chapter 4, comparison between residential areas (AYKO and TORLAK), which has different type of building, it was stated that sewer system cost is significantly high amongst the other infrastructure elements costs. Capital costs of sewer systems of both study areas are approximately 66% in total cost. Therefore in order to reduce the total investment cost of urban technical infrastructure, understanding and evaluating general structure of the sewer system is exceptionally essential. By doing that, determine in which steps of the overall process of installation has great importance for future development decisions. Eventually, evaluating the results of the installation cost elements of sewer system, it can be stated that pipeline installation cost is three times higher than manhole installation. Pipeline and manhole installation costs are 74% and 26% respectively. So compared to overall installation process, it is recommended that reducing pipeline construction cost decrease the total cost considerably. Within the pipeline construction process, trench excavation, retaining support installation and pipe cost have the highest rate in total cost distribution. But retaining support installation has the highest rate of 55.18% of total. Therefore location of settlement and solidity of soil has direct effect on total construction cost. Retaining support installation is carried out just for creating safer working conditions for workers and materials during the construction process. That's why location conditions of site are crucial effect on construction cost of sewer system. Additionally, reducing total length of pipeline decreases pipeline construction cost 16% and 11.8% of overall construction cost. In terms of manhole installation, surprisingly trench excavation for manhole is not significant contributor on installation costs. Number of manhole and depth of manhole are very important factors for reducing construction cost. However, instead of developing technical solutions especially construction stages to the urban infrastructure elements within the urban settlements, main solution should be search in the concept of urban form. 2 dimensional and 3 dimensional urban development alternatives which shaped by building types and number of storey decisions and also land use layout with its alternatives (Multi-layered land use structure) should be the main determinants while decreasing infrastructure investment cost process.

As mentioned before, decreasing land consumption by increased density reduces the total size of the city and provides many benefits in terms of efficient service distribution. However, type of building for residential development seems to be more crucial for public sector. Because all services utilities furnished under the traffic routes. For example; subdivision plans with detached type of building increase total amount of service costs because of increased responsibility area of service provider. On the other hand, "cluster" type of building as an example of urban design project provides reduction for public sector but increase per capita expenditure of end users. Current implementations demonstrate that within the cluster type of building block, all types of services have to be provided by households, because public sector would only be responsible for providing services under the surrounding roads of the building block. For that reason, currently produced urban regeneration and renewal projects as urban design projects provide great amount of savings in terms of infrastructure costs. On the other hand, compared to the development pattern of peripheral area of the cities, those kinds of developments and infill development pattern within the existing structure of the built area effect the current capacity of the service networks and may require additional incremental investments. That's why intense land use pattern of central area of the built environment and dispersed urban development pattern are on active debate. Litman (2004) claims that creating compact land use pattern could be provided by using smart growth and new urbanism strategies and principles. That is true for reducing negative effects of compact urban form such as; increased traffic congestion, lack of green space, air and noise pollution etc. would be achieved by using smart growth strategies and demand management techniques and underground locations for windowless usages, but existing capacity of infrastructure especially sewer, water and electricity system certainly needs additional investment for four times increased density of central area. Therefore, trade-offs between additional investments costs for existing structure and services that scattered or dispersed urban development needs should be examined in detail.

Sustainable urban development that the Expert Group of European Commission recommends to accomplish minimizing consumption of natural resources, minimizing production of waste, minimizing pollution of air, soil and waters and increasing the proportion of natural areas and biodiversity in cities obviously call for to review the current plan production processes for more intensive use of urban land stocks. Although horizontally and vertically mixed, high density urban structure increase the initial cost of infrastructure investments, it may cost efficient for long terms use and provide many benefits for environmental, social and economic life of the cities. And also all drawbacks about compact, hexagonal and underground development pattern can be turned into advantages by urban design projects.

Additionally, developed technical alternatives against trenches in the road network for the installation of infrastructure would have improved and create contribution to existing macro-form alternatives such as; tunneling, reusing existing services and trenchless technology and common trench methods. With common trenching or joint lying, utilities share the costs of installing their elements together in a common trench and reduce disruption to the road network. The main obstacles to joint trenching are coordination, compatibility and cost sharing. Coordination problems can be defeated by use of an independent firm to supervise, design and schedule the installation. Compatibility problems can be solved by proper design and construction materials choice. Cost-sharing methods have been developed related to the utilities potential savings and occupation of space in the trench. This integrated installation is also helped by the main service providers being different departments within the same local governmental unit. The integration of planning and construction makes the most efficient use of limited underground space and minimizing damage to other utility equipment and disrupting the road. There are a number of advantages of sharing space within a service tunnel. These include improved access and minimizing accidental damage, better coordination when managing and maintaining cables and pipes and increased operational safety and reduced risk of damage because the cables and pipes can be inspected. Tunneling also provides shorter distance and reducing high cable costs and transmission costs. The tunnel provides better protection, a longer design life for the cables, improved access to install other cables.

Instead of searching for technical solution by overlapping both planning processes for minimizing public investment cost, reorganizing current planning process and creating more efficient planning structure by using sustainable development strategies and principles seems to be more logical. The objectives of sustainable development are minimizing consumption of natural resources, especially non-renewable and slowly renewable ones; minimizing production of waste by reusing and recycling wherever possible; minimizing pollution of air, soil and waters; and increasing the proportion of natural areas and biodiversity in cities. To achieve these objectives cities themselves should provide many potential solutions using wide exchange of experience to circulate good practice, instead of shifting problems to other spatial levels or shifting them to future generations. Existing spatial planning systems should be strengthened by encouraging ecologically-based approaches, because recommended policy options by the Expert Group report (1996) give a direction to the existing and future development areas of cities to built and reshape them with "compact" form. As previously discussed, "compact urban form" provides many potential solutions to the cities in terms of reducing infrastructure investment cost. The identification of environmental objectives at an early stage in the planning process, the use of targets and indicators, improved forms of public involvement in planning should be encouraged. The organizational patterns and administrative systems of municipalities should adopt the holistic approach of ecosystems thinking. Integration, cooperation, subsidiarity and synergy should be the key concepts for management towards urban sustainability.

Planning should not always seek to "balance" the benefits of development against costs to the environment. Instead, planners should increasingly define environmental capacities and also planning should be "supply limited" rather then "demand driven". Therefore demand management and its strategies for future development should be used more frequently instead of meeting increased demand of development.

However, even this study results in helpful solutions to the existing problems, the stage involving the application of these results requires the decision makers, authorities, and especially the ones having authority in different technical subjects and areas to work together in coherence with an enthusiasm to share their capabilities and authorities. Moreover, since this cooperation will firstly need the overlapping of the annual investment plans of different administrative authorities, this study will merely contribute technically to the solutions of the existing problems.

REFERENCES

Akkiraz, A. 1998. "*Financing public sector infrastructure projects in Turkey through external borrowing: Conventional direct foreign borrowing and private participation as an alternative"*. The Middle East Technical University, Ankara.

Annez, P. 1998. "Livable cities for the 21st century". *Society,* vol.35 no: 4, pp.45-51.

Anwar, S. 2001. "Government spending on public infrastructure, prices, production and international trade". *The Quarterly Review of Economics and Finance,* vol.41, pp.19-31.

Arce, R., & Gullon, N. 2000. "The application of strategic environmental assessment to sustainability assessment of infrastructure development". *Environmental Impact Assessment,* vol.20, pp. 393-402.

Audirac, I., & Shermyen, A. H. 1990. "Ideal urban form and visions of the good life florida`s growth management dilemma". *Journal of the American Planning Association,* vol.56 no: 4, pp. 470-483.

Azizi, M. M. 1995. "The provision of urban infrastructure in Iran: An empirical evaluation". *Urban Studies,* vol.32, no: 3, pp. 507-522.

Azizi, M. M. 2000. "The user-pays system in provision of urban infrastructure: Effectiveness and equity criteria". *Urban Studies,* vol.37 no: 8, pp. 1345-1357.

Baharoğlu, D. 1998. "Coping strategies for infrastructure: How turkey's spontaneous settlements operate in the absence of formal rules". *Habitat International,* vol.22, no: 2, pp. 115-135.

Baxter, A. 1995. "Infrastructure and the life of cities". *Urban Design Quarterly, January,* vol.53.

Biddulph, M. 2000. "Villages don't make a city". *Journal of Urban Design,* vol.5, no: 1, pp. 65-82.

Bierman, S. M. 1999. "*An infrastructure potential cost for integrated land-use and infrastructure planning"*. University Of South Africa.

Blackmore, R., Wood, C., & E.Jones, C. 1997. "The effect of environmental assessment on uk infrastructure project planning decisions". *Planning Practice & Research,* vol.12, no:3, pp. 223-238.

Blais, P., 1995 "*The Economics of Urban Form*", in Appendix E of Greater Toronto, Greater Toronto Area Task Force (Toronto), December

Boarnet, M. G., & Chalermpong, S. T. 2002. "*New highways, induced travel, and urban growth patterns: A "before and after" test"*: University of California Transportation Center and The Environmental Protection Agency.

Boarnet, M. G., & Sarmiento, S. 1998. "Can land-use policy really affect travel behavior? A study of the link between non-work travel and land-use characteristics". *Urban Studies,* vol.35, no: 7, pp.1155-1169.

Bond, P. 1999. "Basic infrastructure for socio-economic development, environmental protection and geographical desegregation: South Africa's unmet challenge". *Geoforum,* vol.30, pp. 43-59.

Breheny, M. 1997. "Urban compaction: Feasible and acceptable?" *Cities,* vol.14, no: 4, pp. 209-217.

Breheny, M. J. 1992, "*Sustainable development and urban development"*. London: Pion Limited.

Briassoulis, H. 2001. "Sustainable development and its indicators: Through a (planner's) glass darkly". *Journal of Environmental Planning and Management,* vol.44, no: 3, pp. 409-427.

Buhrs, T., & Aplin, G. 1999. "Pathways towards sustainability: The Australian approach". *Journal of Environmental Planning and Management,* vol.42, no: 3, pp. 315-340.

Bulkin, I. 1995. "*Infrastructure requirements under conditions of development: The dynamics of urbanization in Indonisia 1990-2020".* Cornell University.

Burchell, R. W., Shad, N. A., Listokin, D., Phillips, H., Downs, A., Seskin, S., et al. 1998. "*The costs of sprawl-revisited"*: The Federal Transit Administration Transportation Research Board.

Burns, P., Hope, D., & Roorda, J. 1999. "Managing infrastructure for the next generation". *Automation in Construction,* vol: 8, pp. 689-703.

Burton, E, 2002 "Measuring urban compactness in UK towns and cities", *Environment and Planning B: Planning and Design*, vol.29, no: 2

Burton, E. 2000. "The compact city: Just or just compact? A preliminary analysis". *Urban Studies,* vol.37, no: 11, pp.1969-2001.

Burton, E., 2001, "*The compact city and social justice"* Environment and Sustainability, University of York.

Cain, N. L. 2000. "*Sprawl costs us all"*: Sierra Club.

Çalışkan, O. 2004. "*Sustainable urban form: Compact city"*. Middle East Technical University, Ankara.

Canning, D. 1998. "A database of world stocks of infrastructure, 1950-95". *Economic Review,* vol.12, no: 3, pp.529-547.

Chiara, J., Koppelman, L., 1969, "*Planning Design Criteria*", Newyork, in corporation with the school of architecture-Pratt Institute, Van Nostrand Reinhold Company,

Chow, F. C., T.Paul, Vähäaho, I. T., Sellberg, B., & Lemos, L. J. L. 2002. "*Hidden aspects of urban planning: Utilization of underground space" The costs of sprawl-revisited literature synthesis "*).

Ciscel, D. H. 2001. "The economics of urban sprawl: Inefficiency as a core feature of metropolitan growth". *Journal of Economic Issues,* vol.35, no: 2, pp. 405-413.

Clark, G. L., & Root, A. 1999. "Infrastructure shortfall in the united kingdom: The private finance initiative and government policy". *Political Geography,* vol.18, pp. 341-365.

Commission of the European Communities, 1992a, *Treaty on European Union.* Brussels.

Commission of the European Communities, 1992d, *Treaty on European Union.* Brussels.

Commission of the European Communities, 1992e, *Treaty on European Union.* Brussels.

Couch, C., & Dennemann, A. 2000. "Urban regeneration and sustainable development in Britain". *Cities,* vol.17, no: 2, pp. 137-142.

Cox, W., & Utt, J. 2004. "*The costs of sprawl reconsidered: What the data really show"*: Thomas A. Roe Institute.

Crane, R. 2000. "The influence of urban form on travel: An interpretive review". *Journal of Planning Literature,* vol.15, no*:* 1, pp. 3-23.

Daniels, T., & Lapping, M. 2005. "Land preservation: An essential ingredient in smart growth". *Journal of Planning Literature,* vol.19, no*:* 3, pp. 316-329.

Ding, C. 1996. "*Managing urban growth for efficiency in infrastructure provision: Dynamic capital expansion and urban growth boundary models"*. University of Illinois, Urbana.

Dowall, D. E., & Whittington, J. 2003. "*Making room for the future: Rebuilding California's infrastructure"*: Public Policy Institute of California.

Durmisevic, S. 1999. "The future of the underground space". *Cities,* vol.16, no: 4, 233-245.

ECOTEC 1993, *Reducing Transport Emissions through Planning*. Report to the Department of the Environment. HMSO, London.

Ennis, F. 1997. "Infrastructure provision, the negotiating process and the planner's role". *Urban Studies,*vol. 34, no:12, pp. 1935-1954.

Erdem, N. 1990. *"Türkiye'de altyapı politikaları ve yap-İşlet-devret modeline bir yaklaşım"*. İstanbul.

Erdemli, M. 1999. *"Effects of infrastructure on urban development"*. Middle East Technical University.

Erdin, H. E. 2001. *"Planlamada su ve kanalizasyon sistemleri proje eşiklerinin değerlendirilmesi (İzmir büyükşehir bütününde bir deneme)"*. Dokuz Eylül Üniversitesi, izmir.

Estache, A., & Sinha, S. 1994. *"Does decentralization increase spending on public infrastructure?"* The World Bank.

Ewing, R. 1997, "Is Los Angeles-style sprawl desirable?" *Journal of the American Planning Association*, vol.63, no: 1, pp. 107–126.

Ewing, R., Pendall, R., Chen, D., 2002 "*Measured Sprawl and Its Impact*", Smart Growth America,

Featherstone, R.E., James, A., 1982, "*Urban Drainage Systems*", Boston, Pitman Advanced Publishing Program.

Feitelson, E., & Papay, N. 1999. "Sharing rights of way along inter-urban corridors: A spatial temporal and institutional analysis". *Transportation Research Part D,* vol.4, pp. 217-240.

Ferguson, E. 1999. "The evaluation of travel demand management". *Transportation Quarterly,* vol.53, no: 2, pp. 57-78.

Ford, L. R. 1999. "New urbanism and theories of good city form". Cities, vol.16, no: 4, pp. 247-257.

Garcia, D., & Riera, P. 2003. "Expansion versus density in Barcelona: A valuation exercise". *Urban Studies,* vol.40, no: 10, pp. 1925-1936.

Golany, G. S. 1996, *"Geo-space urban design"*. New York: John Wiley & Sons, Inc.

Goldman, J. A., Keating, A. D., McKinney, H. J., Rose, M. H., & Troesken, W. 2001. "Investigating urban infrastructure". *Journal of Urban History,* vol.27, no: 4, pp. 520-525.

Goodland, R. 1999. "Decentralizing public services". *Urban Studies,* vol.36, no: 13, pp. 2428-2430.

Gordon, P. and Richardson, H. W. 1997 “Are compact cities a desirable planning goal?” *Journal of the American Planning Association*, vol.63, no: 1, pp. 95–106.

Graham, S. 2000a. "Constructing premium network spaces: Reflections on infrastructure networks and contemporary urban development". *International Journal of Urban and Regional Research* ,vol.24, no*:* 1, pp. 183-201.

Graham, S. 2000b. "Introductıon: Cities and infrastructure network". *International Journal of Urban and Regional Research,* vol.24, no: 1, pp. 114-120.

Graham, S., & Marvin, S. 2002, "*Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition"*. New York: Routledge.

Grahan, S. 2000. "Introduction: Cities and infrastructure networks". *International Journal of Urban and Regional Research,* vol.24, no*:* 1, pp. 114-120.

Guy, S., Graham, S., & Marvin, S. 1997. "Splintering networks: Cities and technical networks in 1990s britain". *Urban Studies,* vol.34, no*:* 2, pp. 191-216.

Guyer, J. P. 1985, "*Infrastructure for urban growth"*. San-Diego: San-Diego State University.

H.Takasaki, H.Chikahisa, & Y.Yuasa. 2000. "Planning and mapping of subsurface space in japan". *Tunneling and Underground Space Technology,* vol.15, no*:* 3, pp. 287-301.

Hales, R. 2000. "Land use development planning and the notion of sustainable development: Exploring constraint and facilitation within the English planning system". *Journal of Environmental Planning and Management,* vol.43, no*:* 1, pp. 99-121.

Hales, T. C. 2001. "The honeycomb conjecture". *Discrete Computational Geometry,* vol.25, pp. 1-22.

Haque, M. S. 2000. "Environmental discourse and sustainable development: Linkages and limitations". *Ethics and the Environment,* vol.5, no*:* 1, pp. 3-21.

Harris, W., Charles, D.N., 1988, “Time Saver Standards for Landscape Architecture” USA, Mc Grow Hill.

International City/County Management Association with Geoff Anderson. 1998. “*Why smart growth: A primer”*. Washington, DC: International City/County Management Association.

Jenks, M., & Burgess, R. 2000, "*Compact cities: Sustainable urban forms for developing countries"*. London: Sporn Press.

Jenks, M., Burton, E., & Williams, K. (Eds.). 1996, “*Debating urban compaction”*.

Jepson, E. J. 2001. "Sustainability and planning: Diverse concepts and close associations". *Journal of Planning Literature,* vol.15, no: 4, pp. 499-510.

Jim, C. Y. 2003. "Protection of urban trees from trenching damage in compact city environments". *Cities,* vol.20, no: 2, pp. 87-94.

Joardar, S. D. 1998. "Carrying capacities and standards as bases towards urban infrastructure planning in india: A case of urban water supply and sanitation". *Habitat International,* vol.22, no: 3, pp. 327-337.

Joseph, E. B., & Gordon, D. 2000. "Hexagonal planning in theory and practice". *Journal of Urban Design,* vol.5, no: 3, pp. 237-265.

Kazaz, A. 1990. "*Türkiye de altyapı yatırımlarının yapısı ve gelişimi". İstanbul* Üniversitesi, istanbul.

Kenworthy, J., & Newman, P. 1993. "*Automobile dependence: The irresistible force?"* Institute for Science and Technology Policy Murdoch University.

Kim, J. A. 2004. "Sustainable development and the clean development mechanism: A south African case study". *Journal of Environment & Development,* vol.13, no: 3, pp. 201-219.

Kim, K.-H. 1997. "Housing finance and urban infrastructure finance". *Urban Studies,* vol.34, no*:* 10, pp. 1597-1620.

Konuşkan, I. 1989. "*Cost of squatter (gecekondu) housing areas to urban economies from the point of view of infrastructural services: A case study from Ankara".* METU.

Kupel, D. E. 2001. "Investigating urban infrastructure". *Journal of Urban History,* vol.27, no: 4, pp. 520-525.

Ladd, H. F. 1992. "Population growth, density and the costs of providing public services". *Urban Studies,* vol.29, no: 2, pp. 273-295.

Leigh, N. G. 2005. "Introduction to the special issue on smart growth". *Journal of Planning Literature,* vol.19, no: 3, pp. 299-300.

Levinson, D. 2003. "Perspectives on efficiency in transportation". *International Journal of Transport Management,* vol.1, pp. 145-155.

Litman, T. 2004a. "*Comprehensive evaluation of rail transit benefits"*: Victoria Transport Policy Institute.

Litman, T. 2004b. "*Evaluating criticism of smart growth"*: Victoria Transport Policy Institute.

Litman, T. 2004c. "*Evaluating transportation land use impacts"*: Victoria Transport Policy Institute.

Litman, T. 2004d. "*Understanding smart growth savings"*: Victoria Transport Policy Institute.

Littlewood, M., 1993, "Landscape Detailing 2", Oxford, Butterworth-Hieneman Ltd.

Malpezzi, S. and Guo, W.-K., 2001 "*Measuring 'sprawl:' alternative measures of urban form in U.S. metropolitan areas*". The Center for Urban Land Economics Research, University of Wisconsin, Madison, WI.

Marcotullio, P., 2001 "*The compact city, environmental transition theory and asia pacific urban sustainable development*", paper for international workshop, Japan.

Marquez, L. O., & Smith, N. C. 1999. "A framework for linking urban form and air quality". *Environmental Modeling & Software,* vol.14, pp. 541-548.

Marvin, S. 1995. "*Demand-side management and urban infrastructure"*: University of Newcastle department of Town and Country Planning.

Marvin, S., & Graham, S. 1993. "Utility networks and urban planning: An issue agenda". *Planning Practice and Research,* vol.8, no: 4, pp. 6-15.

Marvin, S., & Slater, S. 1997. "Urban infrastructure: The contemporary conflict between roads and utilities". *Progress in Planning,* vol.48, pp. 247-318.

Mathur, S. K. 1995. "*Public infrastructure investment decision-making: Multicriteria trade off optimization".* A̧ M University.

Mayhew, L. 2000. "Using geometry to evaluate strategic road proposals in orbital-radial cities". *Urban Studies,* vol.37, no: 1, pp. 2515-2532.

McCluskey, J. 1979, "*Road form and townscape"*. London: Architectural Press.

Mclaren, D. 1993, "Compact or dispersed? Dilution is no solution", *in Built Environment*, vol.18*,* no: 4, pp. 268-284.

Meyer, M. D. 1999. "Demand management as an element of transportation policy: Using carrots and sticks to influence travel behavior". *Transportation Research Part A,* vol.33, pp. 575-579.

Miller, J. B. 1995. "*Aligning infrastructure development strategy to meet public needs".* Massachusetts Institute of Technology.

Moudon, A. V., Hess, P., Snyder, M. C., & Stanilov, K. 1997. "*Effect of site design on pedestrian travel in mixed-use, medium-density environments"* (No. WA-RD 432.1): University of Washington.

Nasimiyu, J. 1994. "*Urban infrastructure management using gis technology"*. Charleton University.

Newman, P. 1993, *"*The compact city: an Australian perspective*", In Built Environment*, vol.18, no: 4, pp. 285-300.

Newman, P., & Kenworth, J. 1999, "*Sustainability and cities: Overcoming automobile dependence"*. California: Island Press.

Nielsen, S. B., & Elle, M. 2000. "Assessing the potential for change in urban infrastructure systems". *Environmental Impact Assessment Review,* vol.20, pp. 403-412.

Nijkamp, P. 1990, "*Sustainability of urban systems"*. England: Avebury Gower Publishing Company Ltd.

Nijkamp, P., Ouwersloot, H., & Rienstra, S. A. 1997. "Sustainable urban transport systems: An expert-based strategic scenario approach". *Urban Studies,* vol.34, no*:* 4, pp. 693-712.

Page, S., Phillips, B., & Siembab, W. 2003. "The millennium city: Making sprawl smart through network-oriented development". *Journal of Urban Technology,* vol.10, no: 3, pp. 63-84.

Payne, R., 1982, "*Drainage and Installation*", London, Construction Press.

Phienwej, N. 1998. "Tunneling for infrastructure development in Thailand". *Tunneling and Underground Space Technology,* vol.13*,* no: 3, pp. 317-330.

Pior, M.-Y., & Shimizu, E. 2001. "Gis-aided evaluation system for infrastructure improvements: Focusing on simple hedonic and rosen's two-step approaches". *Computers, Environment and Urban Systems,* vol.25, pp. 223-246.

Portnov, B. A., & Pearlmutter, D. 1999. "Sustainable urban growth in peripheral areas". *Progress in Planning,* vol.52, pp. 239-308.

Rakodi, C., & Nunan, F. 2002. "*Sustainable urbanization"* (No. HS/676/02E): UN-Habitat UK Government Department for International Development.

Randrup, T. B., Mopherson, E. G., & Costello, L. R. 2003. "A review of tree root conflicts with sidewalks, curbs and roads". *Urban Ecosystems,* vol.5, pp. 209-225.

Ray, K. 1998. "Tunnels and infrastructure for metropolises: The habitat agenda perspective". *Tunneling and Underground Space Technology,* vol.13, no: 3, pp. 313-315.

Robinette, G.O., 1985, "*Barrier free Exterior Design: Anyone can go Anywhere*", New York, Van Nostrand Inc.

Rotmans, J., Asselt, M. v., & Vellinga, P. 2000. "An integrated planning tool for sustainable cities". *Environmental Impact Assessment,* vol.20, pp. 265-276.

Rydin, Y. 1998. "Land use planning and environmental capacity: Reassessing the use of regulatory policy tools to achieve sustainable development". *Journal of Environmental Planning and Management,* vol.41, no: 6, pp. 749-765.

Schuler, R. E. 1992. "Transportation and telecommunications networks: Planning urban infrastructure for the 21st century". *Urban Studies,* vol.29, no*:* 2, pp. 297-310.

Siddiqui, S. 1997. "*Infrastructure, sustainable development and society".* University Of Canada.

Siegel, C. 1997. "*Slow is beautiful: Speed limits as political decisions on urban form"*: A Preservation Institute Policy Study.

Silva, R. T. 2000. "The connectivity of infrastructure networks and the urban space in Sao Paulo in the 1990`s". *International Journal of Urban and Regional Research,* vol.24, no: 1, pp.139-165.

Simon, M., & Simon, G. 1997. "Infrastructure provision, development processes and the co-production of environmental value". *Urban Studies,* vol.34, no: 12, pp. 2023-2036.

Smythe, R., 1986, "*Density-Related Public Cost*", American Farmland Trust,

Steadman, P., 1998 "*Some doubts about the "compact city": experiments with an urban land use, transport and energy model*", COST C4 Final Conference,

Sterling, R. 1997. "Underground technologies for livable cities". *Tunneling and Underground Space Technology,* vol.12, no: 4, pp. 479-490.

Takasaki, H., Chikahisa, H., & Yuasa, Y. 2000. "Planning and mapping of subsurface space in Japan". *Tunneling and Underground Space Technology,* vol.15, no: 3, pp. 287-301.

Thinh, N. X., Arlt, G., Heber, B., Hennersdorf, J., & Lehmann, I. 2002. "Evaluation of urban land-use structures with a view to sustainable development". *Environmental Impact Assessment Review,* vol.22, pp. 475-492.

Timmermans, J. S., & Beroggi, G. E. G. 2000. "Conflict resolution in sustainable infrastructure management". *Safety Science,* vol.35, pp. 175-192.

Tropp, H. 2000. "Sustainable development and the future of cities". *Local Environment,* vol.5, no: 2, pp. 293-295.

Tsai, Y.-H. 2005. "Quantifying urban form: Compactness versus 'sprawl'". *Urban Studies,* vol.42, no: 1, pp. 141-161.

Turabi, A. 1998. "*Kentesel yerleşim alanlarında altyapı ve üstyapı oluşumunun araştırılması"*. Balıkesir Üniversitesi, Balıkesir.

United Nations Centre for Human Settlements, 1990, *Sustainable Cities.*

Unutmaz, H. 1994. "*Toplu konut ünitelerinde yeralan sosyal donatım ve altyapı tesislerinin toplam maliyet üzerindeki etkisi"*. İTÜ, istanbul.

Vojnovic, I. 1997. "*The relationship between the pricing of linear infrastructure and urban development patterns: The metro Toronto exp"*. University of Toronto.

Vojnovic, I. 1999. "The environmental costs of modernism". *Cities,* vol.16, no: 5, pp.301-313.

VTPI, "*Online TDM Encyclopedia*", 2003 Victoria Transport Policy Institute (www.vtpi.org),.

Williams, K. 1999. "Urban intensification policies in England: Problems and contradictions". *Land Use Policy,* vol.16, pp.167-178.

Williams, K., Burton, E., & Jenks, M. 2001, "*Achieving sustainable urban form"*. New York: Spon Press.

Ye, L., Mandpe, S., & Meyer, P. B. 2005. "What is "smart growth?"—really?" *Journal of Planning Literature,* vol. 19, no: 3, pp. 301-316.

Zerah, M.-H. 1998. "How to assess the quality dimension of urban infrastructure." *Cities,* vol.15, no: 4, pp. 285-290.

Zmudzinska-Nowak, M. 2003. "Searching for legible city form: Kevin lynch's theory in contemporary perspective". *Journal of Urban Technology,* vol.10, no: 3, pp.19-39.

"*100 and 150mm water meter installations"* 2002: Manukau Water: A Business Unit of Manukau City Council.

"*100 more policies for implementation"* (No. 10/03- 04-099): International City/County Management Association.

"*Design and construction standards for utility location and other facilities in the right of way"* 2000: Larimer County Road Standards.

"*Environmentalism and smart growth: Forging a new consensus"* 2003: Smart Growth and Livable Communities.

"*European sustainable cities"* 1996. Brussel: European Union Commission.

"*Getting to smart growth"* (No. 01/02 02-202): Smart Growth Network.

"*Smart growth more efficient land use management"* 2004: Victoria Transport Policy Institute.

"*The arts and smart growth: The role of arts in placemaking"* 2003: Smart Growth and Livable Communities.

"*Underground and concealed utilities identification procedures"* 2000: University of Cincinnati.

"*Urban design standards manual - water mains"* 1998: CIC.

"*Urban design standards manual-sanitary sewer"* 1998: CIC.

"*Urban settlement strategies guidelines for the north coast"* 2000

"*Utility tunnels and trenches"* 2002: University of Washington Civil Engineering Services.

"*What is smart growth?"* (No. EPA231-F-01-001A)(2001): United States Environmental Protection Agency.

(WEB_1 2005) (www.die.gov.tr 11.01.2005).

(WEB_2 1995) (http://www.mathforum.org/sum95/suzanne/whattess.html)

(WEB_3 2004) (http://www.newurbanism.org/pages/416429/index.htm)

(WEB_4 2005) (http://euronet.uwe.ac.uk/eurosustcit/landuse/landuse.htm)

"*Urban Sewerage System regulations*", 1998, Iller Bank, Ankara

APPENDIX A

POLICY OPTIONS FOR SUSTAINABLE URBAN DEVELOPMENT

Policy Options for Air

- Action plan for air quality

Constituting an action plan to achieve air quality targets is a way of aiding the implementation of actions devised specifically towards increasing the quality of the air. The Council of Ministers is currently in the process of adopting a Directive on Ambient Air Quality Assessment and Management sets standards for 13 substances and defines the responsibility of Member States in reaching these standards. (EUC 1996)

- Greening the city

It is recommended that the capacity for air re-generation and filtering can be increased by providing more green elements and selecting suitable plant species that maximize the transformation of CO_2 into oxygen. This helps to counter urban emissions, particularly from road traffic. Greening the city is a policy option with a multiplier effect. Apart from cleaning the air, green elements also serve to reduce noise pollution, to assist the formation of suitable microclimatic conditions by reducing the impact of wind, balancing temperature variations and hydrating the air. Furthermore, there are areas that the city should attempt to influence through the spatial planning system, environmental legislation at local level, information and awareness raising. These include supporting energy efficient and "clean" industries; and promoting the use of energy efficient appliances and services. Another important objective of sustainable management in relation to air could be that of reducing problems created by natural phenomena which have affected air quality, such as, for example, the replanting of depleted woodlands on the urban fringe. (EUC 1996)

Policy options for water management

- Collecting storm water

Storm water is quite clean if collected before it touches the ground and mixes with various surface pollutants. It can be utilized for purposes where drinking water quality is not required, consequently cutting down consumption of valuable drinking water which experience substantial treatment processes. Storm water can be collected from roofs of buildings. It can be utilized for watering lawns and other green spaces, for cleaning public spaces such as streets, pavements etc. (CEC 1996)

- Facilitating the infiltration of storm water

The infiltration of storm water into the ground is the ecosystem's way of handling new supplies of water and incorporating it into the natural system. Vegetation and soil can purify water. The use of impermeable surfaces prevents storm water from being infiltrated into the ground. Apart from mixing with pollutants such as oil and heavy metals and transporting them to the waste water system, this disturbs the ground water balance and affects the vegetation. Cities can, through the spatial planning system, promote the use of permeable surfaces wherever possible. Car parks are an example of areas that function equally designed permeable surfaces as with impermeable. (CEC 1996)

- Facilitating the retention of storm water

The high proportion of impermeable surfaces in cities can also be counterbalanced by creating ponds, ditches and wetlands which allow the retention of storm water, rather than eliminating it as quickly as possible through the waste water systems. Retention of storm water is a multiplier solution which reduces the additional pressure on waste water treatment systems, while it enhances the natural purification of the water and enriches the flora and fauna. Storm water retention facilities also have a social impact through the recreational value that water elements add to the environment. (CEC 1996)

- Recycling grey water

Two separate water supply systems, one carrying drinking water and the other recycled washing water (grey water), is an option. It is costly to implement such a system in existing urban areas, except in areas of urban regeneration and other large scale reconstruction sites. These are suitable urban targets for this policy. They can be designed to include internal recycling systems for grey water. Water that has been used for washing purposes can be circulated through a small scale recycling facility and fed into the water system for use in toilets, outdoor taps etc. Attention has to be paid to health issues (i.e. all water must meet minimum standards to minimize health risks and to ensure that no technical harm is caused to appliances). The two-water supply systems also have to be designed in a way that minimize risk of misuse, i.e. preventing grey water being used for drinking purposes by mistake (children especially).

Cities can promote the use of two-water supply systems through the spatial planning system, and by incorporating such requirements into building regulations. Where the installation of complete two-water supply systems is considered unfeasible, the option of installing double sewerage networks may provide a compromise. This involves the separation of waste water into two categories, washing water and toilet waste. The washing water could be treated separately (to remove harmful substances such as phosphorus) and then reused, for example, for agricultural purposes. (EUC 1996)

- Promoting more environmentally friendly sewerage solutions

It is important not only to conserve water, but also to improve the quality of the waste water which is returned to the water system. The use of biological treatment plants has increased, especially the ones based on methods of activated sludge, trickling filters and biorotors. Other forms of more environmentally friendly ways of treating and disposing waste water are also being introduced. These are passive methods which make use of ecological functions and require no technical installations or monitoring of operation and maintenance. These include biological ponds, aqua culture methods, reed beds, artificial wetlands, infiltration etc. The use of such treatment systems, wherever possible, should be encouraged through a series of incentives, subsidies, grants, tax reduction, etc. (EUC 1996)

- Controlling pollution sources

The importance of controlling chemical and other industrial pollution sources cannot be over emphasized. Water is very receptive to pollution, and can transport pollution long distances from its original source, thereby spreading harmful substances throughout the ecosystem. It is therefore important not only for air quality, but also for the quality of water sources, that appropriate pollution control/emission legislation regulations are in place and enforced. (EUC 1996)

- Controlling mineral extraction

Most construction activities include the use of stone material in some form. Apart from stone being a limited natural resource, the extraction of stone material affects not only landscapes but also groundwater areas. The recycling of stone material should be promoted so that the effect of minerals extraction on groundwater quality and balance is minimized. Where the spatial planning system covers mineral extraction, it is important that cities exercise their right to influence rates of extraction, for example by making sure that permits are given only where there is an absolute need. (EUC, 1996)

Policy options for Soil, flora and fauna

- Developing a green structure

The development of a green structure for the city provides crucial links between the city and the surrounding countryside. These can include existing green spaces such as agricultural land, parks, tree plantations and natural forests. Although green belts at intervals encircling the city provide recreational value to citizens, they do not provide the vital interconnection of the green areas which ensures the viability of flora and fauna. Green corridors which actually link countryside to green elements within cities provide the best ecological frameworks for habitats, thus combining an increase in biodiversity with recreational value. (EUC 1996)

- Restoration and enrichment of soil and flora

The improvement of soil and plant-life can be brought about through the upgrading of areas which have fallen into disuse by urban activities, as well as land unsuitable for development due to slopes, instability, flooding and other similar characteristics, by reclaiming and rehabilitating soil and sub-soil. This can be enriched by the greening of unbuilt areas on private property, road networks and open spaces, both public and private. (EUC 1996)

- Increasing bio-diversity

The move away from mono-culture towards increased bio-diversity is an important aspect in the sustainable management of cities. Formal parks and lawns contribute only in a limited way to the natural system, although their contribution to the quality of life of citizens is significant. The natural system consists of a multitude of species of both flora and fauna that are mutually supportive and reinforcing. Mono-cultural green areas in urban systems cannot provide the complex support that a healthy ecosystem requires. The number and size of green spaces that are maintained in a natural state should therefore be optimized. (CEC 1996)

- Setting up city farms

Bringing the natural system into cities through small-scale city farms contributes to greening the city and providing educational value. The inhabitants of cities, especially children, know little about ecosystems and where their food comes from. Large scale farming practice, a centralized food processing industry, transportation and the retail market have become essentially incomprehensible. By setting up small city farms to run on the basis of traditional agriculture, municipalities can make their local environment richer and healthier while raising the awareness of citizens. Furthermore, it is important that where high quality agricultural land is adjacent to urban areas, it is protected from development, for example when the city expands. It should rather be maintained in agricultural use, thereby retaining its functional value while providing the benefits of city farms.

The development of a green structure which consists of some of the most important resource elements in the city, i.e. soil and habitats developed both in natural and human-made ecosystems should be based on the following planning and management principles:

- it should provide safe habitats of a high quality for a diversity of species;
- it should describe clearly the nature and intensity of the various activities that it accommodates;
- it should create a feeling of identity and familiarity in its users and, as a result, respect for its conservation needs;
- it should provide an opportunity for education and enlightenment regarding both the sustaining of such a resource and the innovative techniques used in achieving this;
- it should provide mechanisms for monitoring progress towards attainment of the original goals (quantitative indicators).(EUC 1996)

Policy options for Energy

- Energy conservation as a basic aim

Sustainable energy management has an important role to play in relation to over production, transportation, distribution, consumption and general environmental impact. The undesirable consequences of these activities have extensive effects that extend well beyond city boundaries. While sustainable energy management cannot effectively control all these aspects, it should attempt to influence decisions on behalf of the consumers it represents. This includes the place of energy production as well as the means and safety of production. The same applies to matters of transportation and distribution. Lengthy and potentially dangerous networks can be shortened and made safer through planning and design. Aspects of safety relating to energy consumption range from stricter guidelines for the sitting and mix of land use, and activities to control emissions from the use of various energy sources. (CEC 1996)

- Introducing local energy management systems

The environmental, financial and social consequences of centralized energy management are obvious in all European cities. The adverse effects of energy use have resulted in substantial rehabilitation costs and forcing cities to adopt policies on energy saving and substitution in order to try to improve the local environment. Cities should actively engage in developing a decentralized energy management strategy whereby clear aims and actions are defined, and influence is exercised upon the various public or private operators involved. (CEC 1996)

- Promoting local energy production

Centralized energy production requires fuel to be transported long distances involving substantial energy use for transportation. Similarly, the lengthy energy distribution networks acquire increased risk of leakage and energy loss. Energy production at the local level can minimize these problems and has other benefits in environmental, economic and social terms. Local, or decentralized, energy production not only enhances the overall efficiency of energy production, but also its flexibility, by allowing for the detailed adjustment of production in relation to local demand. (CEC 1996)

- Promoting least cost planning

By applying the concept of least cost planning to energy suppliers it is possible to motivate them to adopt substantial energy conservation programmes while still making profits. The aim should be to sell and charge for a service to the consumer, i.e. a specific level of warmth or light for a room, rather than units of energy. This approach motivates the energy supplier to provide the specified service level using as little energy as possible, thereby conserving energy. The energy saving may be a result of introducing insulation measures for example, the costs of which the energy supplier can transfer to the consumer according to the principles of least cost planning. (CEC 1996)

- Replacing non-renewable energy sources with renewable ones

Most of the energy produced in Europe is dependent on fossil and nuclear fuels. These fuels raise problems concerning scarcity and pollution, and safety. Sustainable management should stress the importance of alternatives in energy production, emphasizing renewable and environmentally friendly energy sources such as solar, wind, water, geothermal, plant oil, bio- gas etc. which minimize the impact on the ecosystem of production, transportation, distribution and consumption of energy by reducing air pollution and climatic change, ensuring safety of production and security of supply into the future. (CEC 1996)

- Co-generation of electricity and heat

Despite the substantial technical development programmes to improve the efficiency of electricity generation, the efficiency of approximately 30% is generally low. The remaining energy is wasted in the form of heat which often is expelled through cooling towers or into rivers. The utilization of this waste heat should be maximized through co-generation of electricity and heat. Co-generation of power and heat can increase the production efficiency to around 90%, thereby significantly reducing the quantity of fuel needed to provide a given amount of useful energy. The city of Helsinki produces 84% of its energy via combined heat and power generation at an efficiency level of 90%. The introduction of heat-power generators in building complexes is also successful in the Netherlands. (CEC 1996)

- Recovery of industrial waste heat

Heat, generated in huge quantities by industrial processes, is often wasted in the form of liquid or hot gases. This waste heat could be used to provide heating for factories, schools, hospitals, and other buildings directly or as feeds to local district heating networks. This option is beneficial both to the industry making an income from selling waste heat, and for the city purchasing cheap energy to feed into local networks. Re-use of waste heat reduces the overall demand for energy, by replacing energy which would otherwise have to be generated. (CEC 1996)

- Production of energy from waste

The careful design of waste processing plants, the use of biomass and the production of biogas from landfill sites and sewage treatment processes are examples of ways of making use of the waste that urban systems accumulate, for the purposes of reducing energy demand from other sources. However, biogas plants are very investment intensive and large amounts of material are needed to make it viable and it may be difficult to collect enough household waste locally. Co-operation with industrial or agricultural producers of biological waste, or with farmers cultivating bio-energy crops, may overcome these problems. (CEC 1996)

- Using sustainable design principles

Cities can use the spatial planning system to attach design and planning to secure significant energy savings. Options such as bio-climatic architectural design, layout, construction materials, insulation techniques, location of activities, densities, orientation of buildings, provision of green structures, microclimate etc. can play an important role, either directly or indirectly, in the achievement of increased energy efficiency of urban systems. For example, high density implies lower energy use in buildings, because apartments and townhouses require less energy for heating and cooling than detached single-family houses. (CEC 1996)

Policy Options for Liquid Waste

- Regular control and monitoring of waste water receptors

Regular checks and monitoring of waste water receptors should be carried out including measurement of the quality of aquatic receptors and surrounding ground area, where waste is discharged. The results of these checks should be the basis for determining priority actions. (CEC 1996)

- Integration with other restrictive policies

Integrating the liquid waste management system with restrictive policies such as a ban on the production of chlophen would result in removal of toxic waste associated with the production process of this chemical and its disposal after use. (CEC 1996)

Policy options for Solid Waste

- Reduction of packaging, and increased use of recyclable and reusable packaging

Excessive packaging should be banned. Reclaiming materials for reuse provides a greater number of jobs than would be lost in the production of packaging. There should be incentives for biodegradable, reusable or recyclable packaging, and imposition of a tax on plastics and other non-biodegradable packaging and materials. A further reduction of waste and energy consumption can be achieved through reduction of recyclable waste and increase in the use of reusable packaging. The use of deposits on bottles, etc. provides a financial incentive to consumers to bring back reusable packaging to the collection centre. (CEC 1996)

- Maximum separation at source

Recovery of materials through the separation of waste at the source of waste production or by mechanical sorter (or other means) at a later stage in the waste disposal chain should be encouraged. The earlier the separation takes place the more efficient and appropriate the waste treatment can be due to the lesser extent of waste contamination. (CEC 1996)

- Local composting of household and garden waste

This local waste treatment reduces the overall amount of household waste to be collected and treated at municipal level, while providing high quality soil for the individual, and a valuable insight into the natural system. Composting therefore constitutes an important part of awareness raising and can have several additional multiplier effects, environmentally, socially and economically. The spatial planning system and building regulations should be used to ensure that appropriate facilities are incorporated into the design and construction of neighborhoods and buildings. (CEC 1996)

- Regulations on use, reuse and recycling of building materials

Construction materials should be selected based on careful knowledge of their impact on waste during construction, use and demolition. The lifetime and the reusability/recyclability of the construction materials are important indicators of how sustainable they are. The lifetime is very much dependent upon the ability to repair and maintain the material/construction. It is possible to make future use of all soil and stone material, wood, cardboard, metal and plasterboard. Only plastic materials prove difficult to recycle. (CEC 1996)

Policy options for Sustainable Accessibility

- Integrated multi-modal urban transport systems

There is a need to develop intermodal transport systems where complementarity rather than competition between modes is promoted. Experience has shown, for example, that investment in public transport will not solve the problems unless combined with action to give public transport priority over private cars. similarly, restrictions on vehicle access to parts of the urban area and restrictive parking measures require accompanying measures to ensure access through alternatives to the car. Otherwise the restrictions may simply lead to the relocation of businesses and retailers outside the restricted areas to areas only accessible by car.

While fully-integrated transport systems are exceptional, many European cities have established more limited, but still innovative, initiatives. These include elements of integrated systems such as:

- measures to manage traffic demand through access restrictions, reserved lanes for certain vehicle types, road pricing, parking policies, traffic telematics tools and methods to restrict urban goods transport;

- measures which give priority to, or otherwise support, public transport, such as park and ride, the provision of tram, trolley bus and light rail systems and intermodality;

- measures which give priority to cyclists and pedestrians; experiments with specialist vehicles and fuels; and measures to influence behavior. (CEC 1996)

Traffic demand management

- Initiatives for car free city **centers**

Furthermore, the European cities forming the "Car-Free Cities Club" work towards reductions in urban car use and possibly a complete ban on the use of the private car during working hours in inner cities. It is important to recognize that despite creating an improved local environment, car free inner cities will only generate a very small share of the required reduction of CO_2, because the greatest part of urban transport and the expected growth are in the urban regions outside the inner cities. (CEC 1996)

- Speed restrictions and traffic calming measures

The installation of traffic calming measures can provide physical support to the enforcement of speed restrictions. However, speed restrictions need to be part of an overall traffic management plan in order to ensure that the positive effects outweigh any negative impacts. Speed restrictions make areas safer and more accessible from the point of view of pedestrians and cyclists, but on the other hand may cause pollution levels to rise as a result of higher inefficiency in fuel consumption. Traffic calming measures should also take into account the needs of emergency services both in terms of the need for speed and comfort for any patients. (CEC 1996)

- High occupancy vehicles lanes can stimulate public transport and car pooling

Turning to consider the use of reserved lanes for certain types of vehicle, the introduction of priority access for High Occupancy Vehicles (HOV lanes) has become common place in parts of the USA but is a relatively new measure in Europe. Its impact can only be fairly marginal, being mainly directed at commuter traffic which itself generally accounts for 25 to 35 % of trips. The use of public transport and car pooling is promoted in Madrid in Spain through the construction of an HOV lane on a main motorway link. The "Systems Select" programme in Rotterdam in the Netherlands has introduced lanes reserved for goods vehicles, public transport, service vehicles and high occupancy vehicles on a number of roads giving access to Rotterdam's port facilities as part of an overall package of measures to reduce congestion. (CEC 1996)

- Road pricing is an instrument with both advantages and disadvantages

Road pricing has been widely advocated both as a disincentive to private car use and as an income raiser. Road pricing certainly has advantages. There is some evidence that it can provide the push for modal shift and it can also provide funding for alternatives to the car. There are, however, several disadvantages to take into consideration. Road pricing measures could divert traffic and lead to more urban sprawl and out of town developments if they are not integrated with planning policy. There are also equity problems. Those on lower incomes and those who pay all their own motoring costs could bear a disproportionate share of the costs. (CEC 1996)

- Local parking policy is an important tool to control traffic volumes

For local authorities parking is an important, and for some the major, tool to control traffic volumes through both price and supply. Parking restrictions, however, do not affect through traffic or, generally, commercial vehicles. However, there are ways in which parking policy can restrict traffic access, for example by giving preference to residents over commuters, limitation of parking provision for offices and other employment sites and priority parking for environmentally friendly vehicles as part of an overall traffic policy. Following the referendum on car traffic in 1992, Amsterdam has chosen parking policy as the main instrument to reduce car journeys. The overall aim of reducing car traffic by 35% will be achieved by reducing commuter parking, giving priority to residents, constructing underground car parks and eliminating on-street parking from many areas or charging at a much higher rate. (CEC 1996)

- Access restrictions on heavy goods vehicles and city distribution centers

Access restrictions on heavy goods vehicles have been part of the traffic policies of many cities for some time. These generally involve limitations for part of the day or night. Some countries and urban areas have begun to look at alternative solutions such as distribution and logistic centers. For example the Netherlands plan to reduce heavy vehicle movements in cities by 50% through the use of such centers. (CEC 1996)

- Priority to public transport

Public transport has declined considerably in most cities over the past 40 years despite large scale investment. Evidence shows that increased investment and other improvements have not succeeded in reducing car traffic and that often any increased usage has come from a shift from cycling and walking. Action is required on levels of service, comfort, image and safety, and actual attention needs to be paid to improving the accessibility of public transport so that it can be used in safety and confidence by people with reduced personal mobility. In addition, reserved lanes, links between networks, and operating aid systems (telematics) require improvements, and the measures need to be integrated with those on car restraint in order to give public transport priority over private transport. Accessibility of public transport need to be improved to take into account the needs of people with reduced mobility - including disabled and elderly people and parents with children in pushchairs. People with reduced mobility are accurately handicapped if the public transport systems are not easily accessible and if they have no alternative transport system. Accessibility is an issue for all public transport users, and besides the specific needs of special user groups, factors such as location of stops and stations, frequency of lines, and both physical and economic accessibility determine the quality of the public transport service. (CEC 1996)

- Park and ride is widely used as a measure accompanying public transport improvements

Park and ride has been widely developed throughout Europe as an accompanying measure to public transport improvements. To be effective park and ride schemes need to include action on signposts, pedestrian links, pricing advantages and security measures for parked cars and drivers, and they need to be accompanied by reductions in parking space in city centers and other dissuasive measures for cars. (CEC 1996)

- A range of policy and technical initiatives are deployed to change travel behavior

A particular feature of public transport policies in a number of cities in recent years has been the reintroduction of trams and trolley-buses. Other cities have invested in light rail systems. Light rail systems that serve both the town centre and outlying suburbs have been introduced in Manchester and Sheffield. At the same time as a range of initiatives is being developed to improve public transport and reduce the use of private cars, it is important to recognize that the car is difficult to replace for certain journeys. This is particularly true for trips around urban areas for which fixed route public transport systems are often inappropriate and taxis are relatively expensive. Partly in response to this challenge, a number of schemes are being developed in Europe to encourage modes intermediate between private and public transport. These include car sharing schemes as, for example, in Berlin and community taxis to service low density areas. (CEC 1996)

- Priority to cyclists and pedestrians

Measures to give priority to cycles and pedestrians should be much more seriously considered, as they have clear benefits, principally low capital cost and very limited impact on the environment. In addition, as a large proportion of urban trips are minimized (around a quarter less than 3km in Germany and the UK) there is enormous potential to shift these short trips from the car to cycling and walking.

- Cycling and walking are effective transport alternatives for short distances

Public transport finds it difficult to accommodate short distances, especially when such trips have their origin and destination in suburban areas. The bicycle is closest to the journey time, door-to-door capabilities and flexibility of the private car, and in many ways a more appropriate substitute than conventional fixed route public transport systems. Cyclist and pedestrian friendly planning requires the prevention of detours and waiting times. The network of cycling and walking routes should be dense to allow direct access to any destination. Connecting paths, shortcuts, passages through buildings, and underpasses or bridges to overcome obstacles such as rivers, rail tracks or motorways can reduce trip length. Waiting times should be kept as short as possible, for example by providing time saving traffic light phases for cyclists and pedestrians, and traffic light bypass options for cyclists turning right. Cyclists and pedestrians must also be able to move safely and without fear. Points where conflicts with other transport modes are likely should therefore be removed, and social control along the routes can be used to prevent feelings of fear. Various measures such as traffic calming and speed reduction, emphasis on visibility, prevention of blind areas, safe design of intersections with cycle paths, advanced stop lines for cyclists, and separate lanes for cyclists going straight ahead can improve traffic safety. Cycling and walking should also be made pleasant and convenient. Measures such as wide pavements and separate cycle paths, leveled-off or continuing pavements and cycle paths at intersections, pedestrianisation schemes, removal of obstacles such as curbstones, smooth surface on cycle paths, and speed humps that do not obstruct bicycle traffic all contribute to increasing the pleasure and convenience of cycling and walking. The development of green corridors based on transport routes, principally footpaths, cycle ways and waterways, to form a network of "greenways", is also a way of enhancing the environmental quality of the cycling and walking environment. Cycling can further be promoted by providing secure bicycle parking facilities near public transport stations, shopping centers, schools, public buildings etc., and by allowing the transport of bicycles on public transport. (CEC 1996)

- Experimenting with specialist vehicles and fuels

Electric/hybrid vehicles could be introduced, especially for commercial task to cope with air quality problems. As with electric vehicles, alternative/reformulated fuels could be introduced on a regional/urban level to address a particular local air quality problem. These measures do not contribute towards solving the congestion problem, and in some circumstances simply displace the pollution from the urban area to the area around power stations. (CEC 1996)