# SPATIAL REQUIREMENTS OF FIRE STATIONS IN URBAN AREAS: A CASE STUDY OF ANKARA

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**SPATIAL REQUIREMENTS OF FIRE STATIONS IN URBAN AREAS: A CASE STUDY OF ANKARA**

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## ABSTRACT

### SPATIAL REQUIREMENTS OF FIRE STATIONS IN URBAN AREAS: A CASE STUDY OF ANKARA

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Fires, with their sudden appearance and destructive character, cause property losses beside much more death and injury especially in cities. Providing fire safety is a multi-faceted context that is related with issues such as staff, vehicle and equipment, function, organization, technology, level of education and consciousness. These are related, directly or indirectly, with spatial organization that is the other side of the issue: they affect space or they are affected from space. In research context, the fire stations are evaluated as a unit of emergency and land use element of urban space. By associating the concepts related to emergency management and to urban scale, the space-time dimension of the issue is examined in urban areas. This research bases on the spatial deficiencies of fire stations in urban areas which are important reasons of the fire losses. It is examined that at which level spatial requirements in the literature are in the related laws and regulations in Turkey. Site selection and design criteria of fire stations are evaluated with the available information about several implications in Ankara case study. As a result of the interviews that have been made to top executive of fire station, it is found that the process of the site selection and design of the fire stations is going on with subjective experiences in urban space. In conclusion of the research, it is displayed that the decisions about the site selection and design of the fire stations are related to not only population criterion, but also much more issues in macro-meso-micro scales. It is considered that the set of multi-criteria that are reached in this regard will provide contribution in legal organization and developing the standards.

**Key Words:** Fire Station, Response Time, Coverage Area, Urban Physical Space, Urban Scales, Urban Design

ÖZ

**İTFAİYE İSTASYONLARININ KENTSEL ALANLARDA MEKANSAL GEREKSİNİMLERİ: ANKARA ÖRNEĞİ**

Hacıoğlu, Çiğdem
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Tez Yöneticisi: Doç. Dr. Mehmet Adnan BARLAS

Aralık, 2010, 123 sayfa

Yangınlar, ani oluşumu ve yok edici karakterleriyle, özellikle kentlerde çok sayıda ölüm ve yaralanma yanında büyük maddi kayıplara neden olmaktadır. Yangın güvenliğinin sağlanması, personel, araç ve donanım, işlev, organizasyon, teknoloji, eğitim ve bilinç düzeyi gibi konularla ilişkili çok boyutlu bir olgudur. Bunlar, konunun bir diğer boyutu olan mekansal düzenlemelerle doğrudan ya da dolaylı olarak ilişkilidir; mekandan etkilenir ya da mekanı etkilerler. İtfaiye tesislerinin kentsel bağlamda mekansal açıdan yetersizliklerinin, yangın kayıplarını arttırıcı önemli bir neden olmasını temel alan bu araştırma, kentsel ölçekte yasal araçların geliştirilmesi için itfaiye tesislerinin yer seçimi ve tasarım ölçütlerini belirlemeyi amaçlamaktadır. Türkiye'deki ilgili mevzuatta, literatürde yer alan mekansal ölçütlere hangi düzeyde yer verildiği araştırılmış, bu doğrultuda, yasal araçların yetersiz ve yüzeysel olduğu görülmüştür. İtfaiye tesislerinin yer seçim ve tasarım kriterleri, Ankara örneğinde yer alan bir kaç uygulama ile birlikte, elde edilebilen veriler dahilinde incelenmiştir. İtfaiye üst düzey yöneticileriyle yapılan görüşmeler sonucunda, itfaiye tesislerinin kentsel alanda yer seçimine ve tasarımına ilişkin sürecin de, öznel deneyimlerle yürütüldüğü görülmektedir. Araştırma sonucunda, itfaiye tesislerinin yer seçimi ve tasarım kararlarının, salt nüfus ölçütüne bağlı olmadığı;

çok sayıda konunun makro-mezo-mikro ölçeklerde bu kararları belirlediği ortaya konulmuştur. Bu doğrultuda ulaşılan ölçütler setinin, yasal düzenleme ve standartların geliştirilmesine katkı sağlayacağı düşünülmektedir.

**Anahtar Sözcükler:** İtfaiye Tesisi, Yangın Yerine Erişim Süresi, İtfaiye Kapsama Alanı, Kentsel Fiziki Mekân, Kentsel Ölçekler, Kentsel Tasarım

Dedicated to Dicle Koğacıoğlu, Türkan Saylan
and the others who feel and shoulder responsibility for all...

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# CHAPTER 1

# INTRODUCTION

## 1.1. Context and Scope

Fire is sudden and fatal. These lines about fire scenes, quoted from a daily newspaper, depicts on of the most frequently seen problem about fire events and fire intervention in Turkey. There are many reasons and results of these serious complex phenomena.

> "... This morning a fire, which occurs at about 05.00 am because of the electric contact, started in a two storey timbered house at Isparta. Kemal Inan (53), who realizes that the fire started at his house, saved his son Ferdi (14) first and then saved his daughter Pelin by throwing them to the courtyard from window. After then, he turned back to save his wife Belkıs (39) who was stuck in the house but he couldn't exit. Fire was quenched by fire crews after a great effort at about 09.30 am... (Erçakır, 2009)"

> "The fire, which started in Karabuk fire station yesterday at 18.45, spread quickly in strong winds. Meantime, a lot of difficulties came up. Water of fire station truck was exhausted and old fire hoses blown out because of high pressure water feeding. Fire crews, who came from surrounding towns and cities for help, came into action. The fire was controlled after a long endeavor (Atay, 2005)".

Looking from a broad perspective, the importance of the issue is referred to as seen below. The approach and questions implied by Altan (2005) can also be discussed as a subject of space in urban areas.

> "... Frequently burning forests, fires which occur because of electric contact or gas explosion, factory fires which are hardly controlled by fire crews who come from surrounding towns and cities for help, fires in which all of the houses burn down, etc. are announced with a headline like "having a near miss from a catastrophe"… It can be understood whether the communities close to "sustain their existences" or close to "extinction"… If a documentary research on fires and fire fighting from past to present is made in Turkey, most probably we would face a tragedy of primitivity with another primitivity which is about earthquake and emerge more dominantly day by day… How we concern about the world of firemen? What is the total budget of the fire station associations? What are the conditions of equipment? What are the other necessities? Why firemen choose this job? How is the firemen's' life conditions and How is their salary? What is the condition of our firemen's when it compares with the condition of firemen in Sweden, Germany or Belgium?" (Adapted from Altan, 2005).

The deficiencies regarding the fire service are again mentioned by Altan in 2009, implying the importance of improving fire response services in order to achieve modernisation.

> "... I wonder if one day the condition of equipment, staff and also <u>completely all of the structure of fire stations</u> will be clear. Such a benchmark must be accepted as a real <u>indicator of modernization</u>..." (Altan, 2009).

Statistical data produced by the Centre of Fire Statistics and presented by Wagner (2006) show that how serious the fire issue is. At the beginning of the 21$^{st}$century, the population of Earth is 6.300.000.000 inhabitants, who annually experience a reported 7.000.000 -8.000.000 fires with 70.000 –80.000 fire deaths and 500.000 –800.000 fire injuries (Wagner, 2006, p.6).

At that time, the population of Europe is 700.000.000 inhabitants, who annually experience a reported 2.000.000 -2.500.000 fires with 20.000 –25.000 fire deaths and 250.000 –500.000 fire injuries (Wagner, 2006, p.6).

The values of fires and fire deaths in Europe are approximately three times more than the average of the world values respect to the populations. These great differences between the values shows us that population cannot be an only indicator effecting fire events and fire deaths or injuries.

General distribution of fire origins and fire deaths by fire origin in the world are given in Figure 1-1. Fires originated from dwellings and other buildings causes 90 per cent of the deaths occurred by the fire in the world. It is strategically observed that fire rate is higher in urban settlements where urbanisation rate and population density are high (Sarikaya, 2001, p.151).

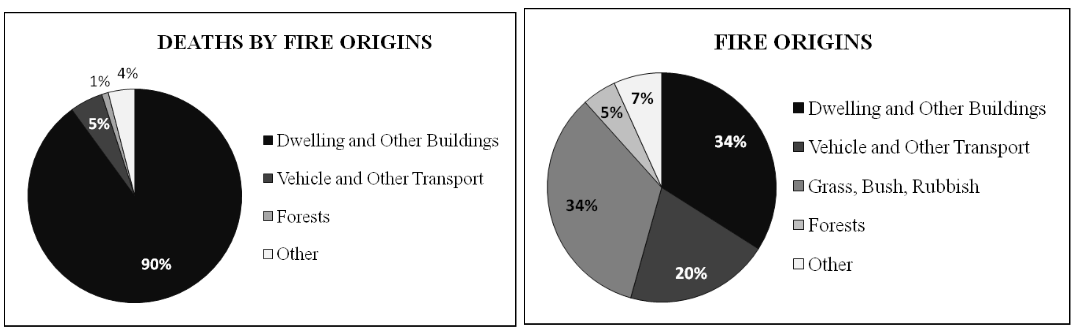


**Figure 1-1** Distribution of Fire Origins and Fire Deaths by Fire Origin in the World (Adapted from Wagner, 2006, p.8-9)

Considering the relation between urban physical space and fire response facility, fire stations as a land use element, have an important role in decreasing fire losses. Balamir (1966, p.ii) explains the important role of fire stations by expressing them as a public service.

> "…the rapid urbanization in Turkey necessitates that public services be taken into consideration with greater vehemence than ordinary. In addition, the municipal fire station is one of the institutions that contribute to the health of the physical make-up in an urban environment."

Fire services, as being an emergency response unit, are differentiated from the other public facilities. Therefore, many spatial requirements are specific to the fire stations in terms of emergency response concept such as having a location to provide quick response to fire scene. When the expert opinions, quantitative and qualitative data are examined in the case study of Ankara, the fire stations are spatially inadequate at urban level.

Provision of fire safety by improving fire services is a multi-faceted phenomenon related with issues, such as staff, equipment, vehicle, function, organization and technology. These issues are related directly or indirectly with spatial organization. They affect space or they are affected from the space. Options to improve the quality of fire services are stated by Mahmud and Indriasari (2009, p.87) which are classified according to the issues, related with fire safety as given in Table 1-1 below;

**Table 1-1**Spatial Relations of Options to Improve the Quality of Fire Service

<table>
<tr><th>Spatial Relations</th><th>Issues</th><th>Options</th></tr>
<tr><td rowspan="3">Direct</td><td>Space (Macro Scale)</td><td>Propose a new Fire Station/Emergency Medical Service-EMS station</td></tr>
<tr><td>Space (Meso Scale)</td><td>Re-location of the existing station</td></tr>
<tr><td>Space (Micro Scale)</td><td>Propose an extension of the existing station, an addition of a new fire hall to the existing station</td></tr>
<tr><td rowspan="4">Indirect</td><td>Staff</td><td>Provide an addition of staff to each platoon</td></tr>
<tr><td>Equipment & Vehicle</td><td>Provide an addition of new vehicles (fire trucks or ambulances)</td></tr>
<tr><td>Function & Organization</td><td>Improving the types of services (such as fire prevention, fire suppression, rescue (e.g. traffic accidents, ice/water rescue), hazardous materials response, EMS response, emergency medical transfers, and disaster services) provided by the station</td></tr>
<tr><td>Technology</td><td>Service adaptation to recent technology</td></tr>
</table>

Adapted from (Mahmud et al., 2009, p.87)

This study is not concerned with the spatially indirect issues. These issues are only mentioned if they contribute to the spatial requirements of fire stations in urban areas. Mainly, in this thesis, the focus will be on defining spatial requirements of fire stations to determine the criteria according to the urban scales.

## 1.2. Purpose, Research Questions and Hypothesis

This research is based on fire stations' spatial deficiencies in urban areas; which are important causes of the fire losses, and aims to define site selection and design criteria of fire stations in urban areas to improve regulations. For developing the theoretical framework of the research aim to focus on the questions below:

- What are the most important indicators of site selection and design of fire stations?
- What are the criteria on fire stations' spatial requirements at the urban scales?
- What are the legislative regulations related to the spatial requirement of fire stations?
- What is the current site selection and design process of fire station in Ankara?

In accordance with these questions, the main hypothesis in the thesis is that "Although fire stations are critical public facilities, the legal tools related to fire stations spatial requirements are insufficient and superficial which is causing subjective practices of the current process". The sub-hypotheses of this research are presented below:

- Fire stations are "critical public facilities", so it is necessary to use rational, inclusive and integrated approaches on their location and design decisions.
- The concepts on "time and space relations" are important components to define urban fire stations' spatial requirements.
- The legislative regulations are insufficient and superficial in Turkey.

- The current fire station site selecting and designing process are going on “subjective practices” in Ankara, the capital of Turkey.
- The determination of urban fire stations spatial criteria is necessary to improve legislation.

### 1.3. Method and Outline

Firstly, the literature is reviewed, criteria are evaluated in the case study and the administrators of Ankara Fire Department are interviewed. In addition, the related legislation is evaluated to determine the spatial criteria of fire stations in urban areas.

The literature including the international standards and the case studies contribute to process of determining fire station spatial requirements are reviewed. Within the survey, it is seen that the rational approaches including quantitative and qualitative methods such as multi-criteria evaluations, mathematical models, performance evaluation are used. In order to determine the criteria within the scope of this thesis, the most important components of these models and evaluations including response time and coverage area are taken into consideration.

It is examined that whether the current related legislation in Turkey meet the spatial requirements found in the literature. Accordingly, Municipality Fire Department Regulations and the regulations within Development Law 3194 are reviewed.

The clues are searched about site selection and design of fire station within the scope of interview. In order to provide flexibility through the interview and also to reach all of the situations and opinions related spatial dimensions in a wide perspective; a face to face-unstructured interview is preferred. The examples of fire reports, correspondence by institution and experiences mentioned by administrators are evaluated. The preliminary preparation for the interview, including the questions and requested data is summarised in the Appendix IX and X.

The organisation of the remainder of this thesis is explained as follows. The general perspective and the importance of the thesis are mentioned in the introduction chapter. In the second chapter, literature regarding definitions and concepts about fire response, site selection and design criteria, classification of criteria according to urban scales and relevant legislations are reviewed. In Section 3, case study of Ankara is explained with the help of interview and several examples. Site selection and design criteria of fire stations are analysed and discussion is followed in Section 5, by presenting a guideline about location and design criteria of fire stations. Additionally the criteria classified according to urban scales to assist implementation processes. In the last section, the conclusion of this thesis and recommendations for further studies are presented.

The flow of research methodology is given in the Figure 1-2, and the focus of thesis is presented through a logical framework in the Figure 1-3.

In the logical framework, Fire Safety Issues except space, Urban Physical Structure except urban design and Realization section including Implementation, Property, Actors and Funding Steps are out of the scope of the thesis. The logical framework is presented in order to emphasize the focused part of this multi-faceted topic.

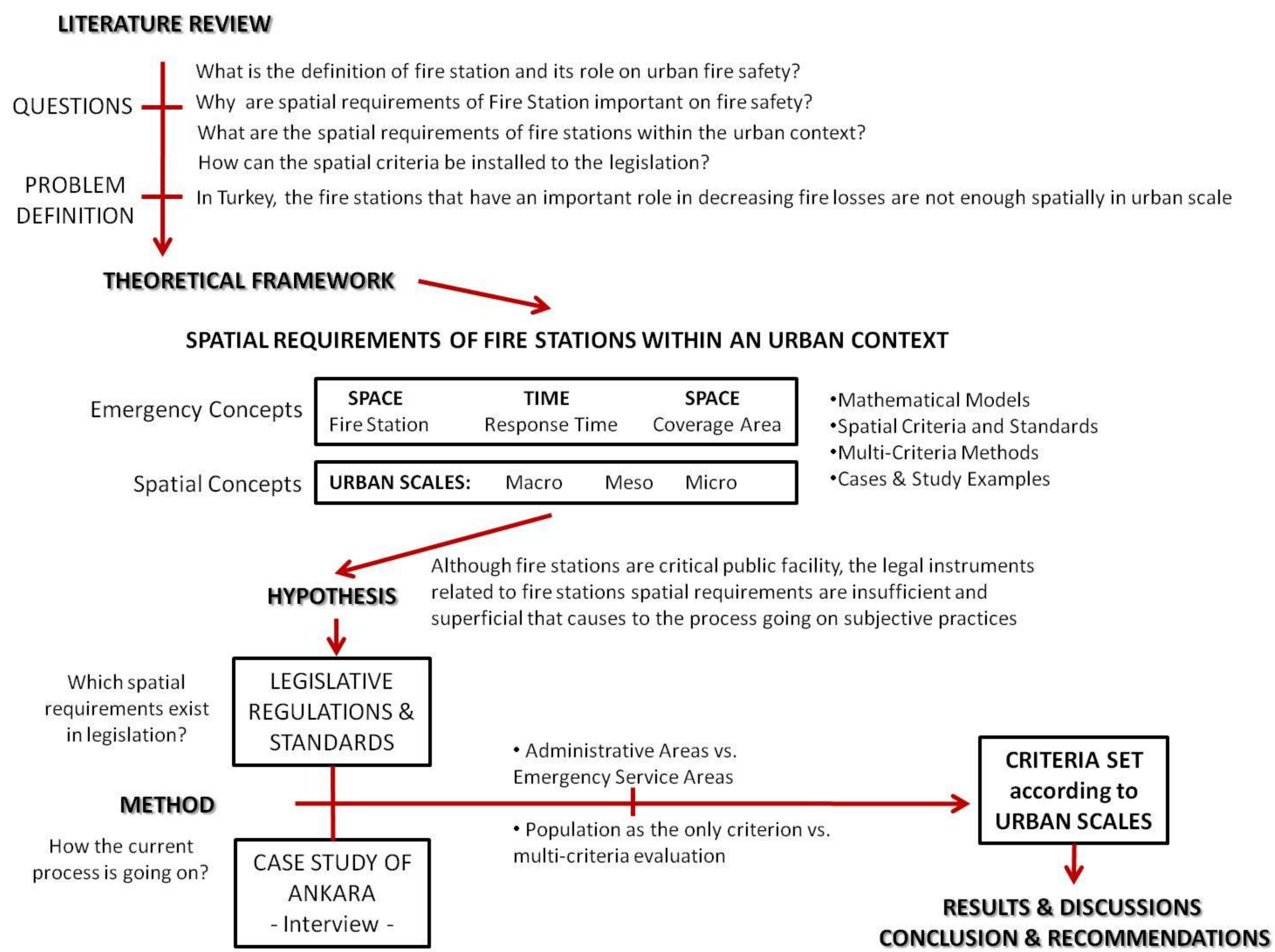


**Figure 1-2** Flow of the Research Method

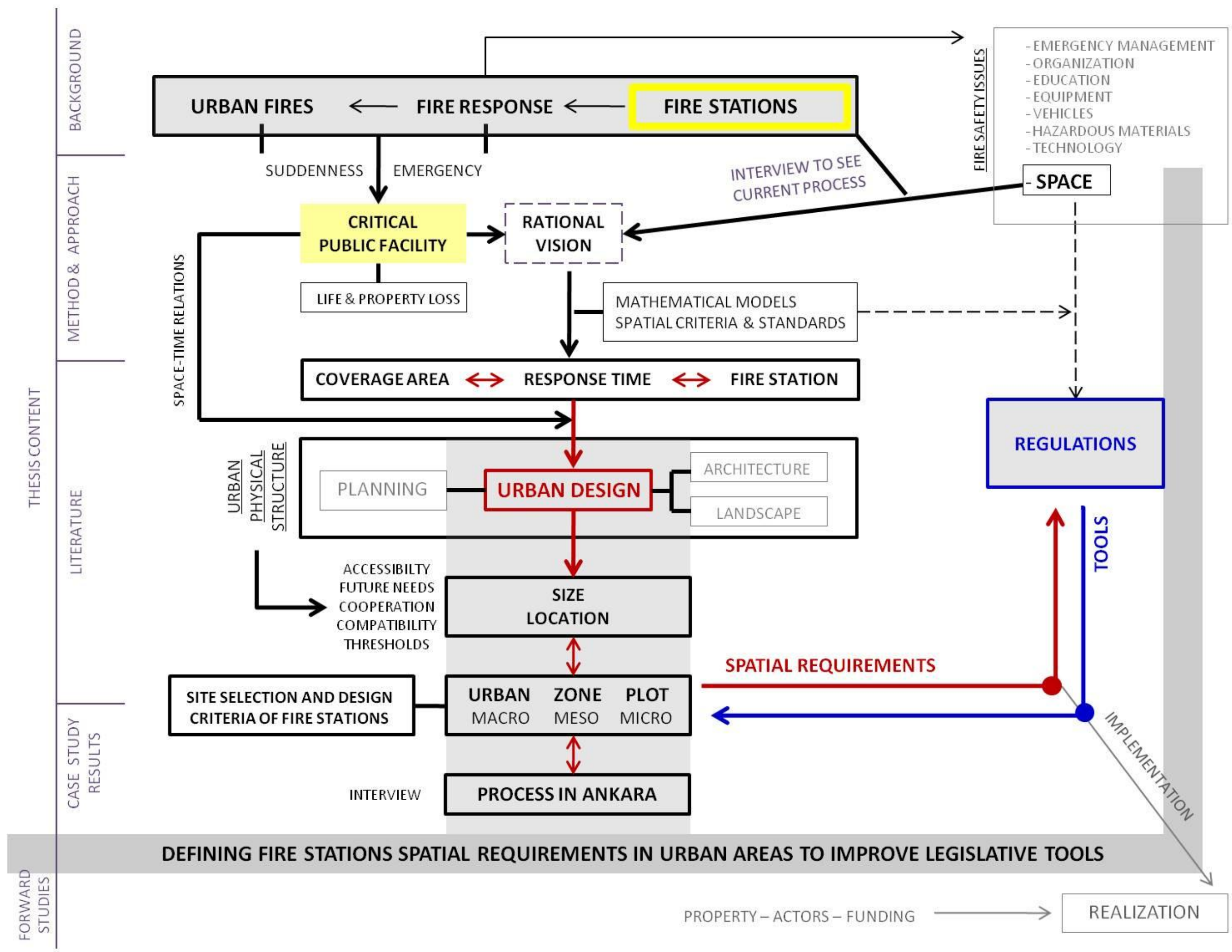


**Figure 1-3** Logical Framework

# CHAPTER 2

# LITERATURE REVIEW

In this section, firstly definitions related to emergency fire response are explained in order to clarify the criteria among site selection and design of fire stations within in urban areas. Then, legislation are explained in detail.  In the following section, review about the concept of urban scale is presented so as to classify the criteria according to the relevant urban scales.

## 2.1. Definitions and Concepts about Fire Response

Fire is defined as any instance of uncontrolled burning, including combustion explosions and fires out on arrival according to The National Fire Protection Association - NFPA (2003, p.119). Fire is one of the emergency situations with its sudden and fatal character. Providing immediate and effective response to fires is important because emergency is a situation that poses an immediate risk to health, life, property or environment.

Response means activities designed to address the immediate and short-term effects of the disaster and/or emergency or with its second meaning the deployment of an emergency service resource to an incident (NFPA, 2003, p. 288). Location of the emergency facilities has an impact on immediate response.

Emergency facilities have a unique characteristic in the way they measure benefits. Typically, the objective of facility location problem is either to minimize costs or maximize benefits. In the case of emergency services, the objective is often stated as the minimization of losses to the public (Aly and White, 1978; Mahmud and Indriasari, 2009, p.87).

Fire-Fighting Operations including rescue, fire suppression, and property conservation in buildings, enclosed structures, aircraft interiors, vehicles, vessels, aircraft, or like properties that are involved in an emergency situation (DoDI, 6055.06, December 21, 2006, p 16). Within the scope of this thesis, structural fires, which usually appear in urban space, are considered rather than wildfires such as forest fires.

The main components of emergency fire response are related with the concepts of space-time relations as presented in Figure 2-1.

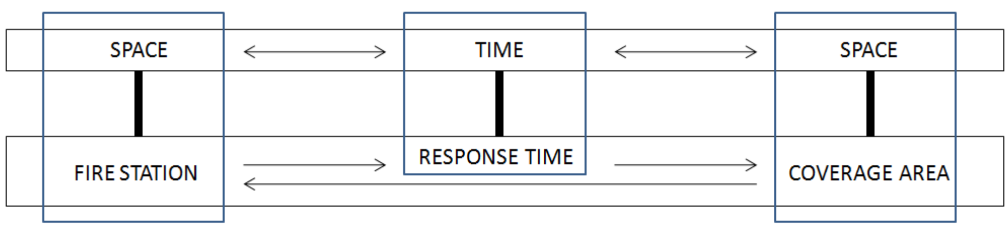


**Figure 2-1** Space and Time Relations within the Scope of Fire Response

Basically fire station can be defined as one of the landuses within an urban space, which is responsible from fire scene placed in another urban space called coverage area. Emergency fire response consists of accessing from a fire station to a fire scene in its coverage area within the targeted time period called response time. Fire station, response time and coverage area concepts are explained in the following sections.

### 2.1.1. Fire Stations

Fire station has various definitions. According to Integrated Planning Act (IPA, 1997), fire station is one of the emergency service facilities which mentioned within the definition of ‘community infrastructure’. According to Poerbo (2001, p.203), fire station is a public facility. Fire station is also stated as an activity area included in Neighbourhood Centre (Davies, 2007, p.42). In Turkey, fire station is classified as one of the urban service areas or administrative areas.

Fire services, as being an emergency response unit, are differentiated from the other public facilities. Therefore, many spatial requirements are specific for fire stations in terms of emergency response necessity.

In the literature, fire stations are mentioned according to many indicators such as settlement character (urban, suburban or rural stations), type (headquarter/main, central, satellite or sub-station), permanency (permanent or temporary stations), service periods (auxiliary/support, day shift or full time services), facility types regarding other emergency management services (stand-alone, joint/ integrated/ combined or shared-use facilities), responsibility zones (owned by municipality, army or private company), organization (career or voluntary),size (small, medium or large) and future needs (additional fire company, training area, community room for public interaction or reserve apparatus storage needs). These indicators of fire stations influence the spatial requirements through the planning and design process.

Some of the fire stations have administrative capabilities called headquarters. Balamir (1966, p.28) states that, the headquarters consists of all the civil and administrative personnel related to the whole system and of a force however, it will also supply the heavy appliances and stationary establishment for the use of whole department.

A fire station supports the needs of the fire department and the community in which it is located. It must accommodate extremely diverse functions, including housing, recreation, administration, training, community education, equipment and vehicle storage, equipment and vehicle maintenance, and hazardous materials storage. While it is usually only occupied by trained personnel, the facility may also need to accommodate the general public for community education or outreach programs (Mion, 2009). Likewise Poerbo (2001, p.203) states that a fire station serves many purposes such as garage, classroom, dining hall, fitness centre, training area, community centre and mixed-use facility.

According to Federal Emergency Management Agency United States Fire Administration - FEMA (1997, p.4), a fire department facility is defined as any building or area owned, operated, occupied, or used by a fire department on a routine basis which may include fire and rescue stations, training academies, and communication centres.

As an example, in the district of Columbia Fire Department (2006, p.4), generally all stations have at least an engine and an ambulance or paramedic unit. About half of the stations also have a ladder truck, a number of stations house a battalion or deputy fire chief and a few have a heavy rescue squad or other special operations unit.

National Fire Protection Association (NFPA) defines the primary functions of the fire station in the relevant code numbered 1201 as presented below (FEMA, 1997, p.21);

- fire prevention and risk reduction,
- fire suppression,
- rescue and emergency medical services,
- hazardous materials response, and
- disaster planning.

### 2.1.2. Response Time

Response time refers the time that begins when units are en route to the emergency incident and ends when units arrive at the scene according to NFPA (2003, p.288). NFPA defines that the total time of fire responding is distributed as dispatch time, turnout time and travel time from the station to the fire incident scene. In brief, response time is the elapsed time, in minutes, from when the first vehicle is dispatched to the time when the first vehicle arrives at the emergency scene. Dispatch Time is the point of receipt of the emergency alarm at the public safety answering point to the point where sufficient information is known to the dispatcher and applicable units are notified of the emergency (NFPA, 2003, p.288). Turnout Time is the time beginning when units are notified of the emergency to the beginning point of travel time (NFPA, 2003, p.288). Travel Time is defined as the time that begins when units are en route to the emergency incident and ends when units arrive at the scene (NFPA, 2003, p.288; DoDI 6055.06, December 21, 2006, pp.16-18).

Since fire is unpredictable, if it is out of control at the initial stage, it may cause great damage and serious loss (Chiang and Lin, 2007, p.2). Fire grows rapidly up to flashover phase, in which a fire generates enough heat and combustible gasses to cause almost explosive fire conditions. At the end of this phase, oxygen inside is exhausted and the temperature inside is nearly 200 degrees Celsius. For the victims inside, a quick response in this period significantly improves chances of a successful rescue and it must also be considered that if a person has stopped breathing and brain damage from oxygen deprivation begins within 4 minutes (Ertugay, 2003, p.53).

In emergency facilities, the response time or travelled distance is a crucial parameter to measure the quality of emergency services. Quicker response will save more properties and lives from losses and damages (Mahmud and Indriasari, 2009, p.92). In other words, response time is a critical component in the control and mitigation of an emergency incident. For this reason, understanding the standardized element of response time is important in order to measure its response effectiveness for a fire department.

Response times are a primary benchmark which can be defined as a function of area covered, traffic infrastructure capacity, equipment capacity and staff to respond (Queensland Government, 2007, p.94).

There are various factors influencing the response time and the generation of fire rescue calls by a given population such as settlement character. Among them are geography, road networks, age and density of population, and age and quality of the building stock (Spotsylvania County, 2009, p.13-19).

Physical site characteristics, travel speeds, traffic volume are directly related to overall response times. Average travel speed can provide clue of coverage area according to a given response time. In order to evaluate the average speed it may be useful to classify the roads as main roads and residential roads, as well as taking into account of the impact of the time of day (rush hour vs. non rush hour) and season (summer vs. winter) on travel speeds (Erkut et. al., 2001, p.2).

According to Habibi et al., the response time of each station is depended to its area of action (2008, p.3308).Response time targets are differentiated according to the character of coverage area. For instance, the response time for urban characteristic is shorter than for rural.

### 2.1.3. Coverage Area

Coverage area or response area are defined as the fire station’s area of action (Habibi et al, 2008, p.2). According to Wu and Ren (2009, p.778), coverage area is the responsibility zone or territory of a fire station. Another definition of coverage area is the coverage site within demand region or travel time zones as mentioned by Mahmud and Indriasari (2009, p.98). Balamir (1966, p.1) defines coverage area as the efficiency zone of fire stations, and according to Liu et al (2006, p.364), it is fire station buffer covering.

Considering the definitions in there viewed literature, coverage area can also be defined as the responsibility area which is served by a fire station within a standard, targeted response time period.

According to Erkut et al. (2001, p.3), the decision problem on determining coverage area has three main components which are demand points, fire station locations, and travel distances. Coverage area is determined by various indicators, such as population, risk zones, density of demand points, annual call amount and coverage radius.

An urban area with high population, high road traffic rate, diverse land use and heterogeneous human activities has a high demand for public facilities, including emergency facilities (Mahmud and Indriasari, 2009, p.92)

The Fire and Rescue Commission of Spotsylvania County (2009, p.18) specifies the goal as reducing the response areas for the stations exceeding 1,500 calls annually. The response areas for these stations should be reduced to 3 miles in order to promote better response times.

The coverage area for each station varies in size with respect to location within the district. An area within the desired service radius of a fire station should be determined according to its density (The Fire and Rescue Commission of Spotsylvania County, 2009, p.18).

According to Wu and Ren (2009, p.778) the size of the response area for each fire station should be determined by the features of different objects, being protected vary in such factors as building density, population density, and economic density, so the potential fire losses are also different. As presented by Lall and Deichmann (2009, p.2) economic density causes higher concentration of people due to economic activities in the zone. Additionally, type of required infrastructure changes according to the type of economic density of that zone, such as industrial zones, central business districts.

Conventional facility location models only define a facility's service area simply as a circular-shaped region based on a specified radius, by a circular coverage (Mahmud and Indriasari, 2009, p.88). According to Mahmud and Indriasari (2009, p.87), the shape of total service area covered by emergency facilities such as fire stations is influenced by the road accessibility.

In the study results presented by Mahmud and Indriasari (2009, p.99), coverage could be improved by providing better locations for fire stations even if the number of fire stations and their travel times are same as the existing situation. According to EnviroIssues and Juan, the new fire station is expected to maintain or improve current service levels and response times for the primary response area and maintain or improve response times, system-wide (2008, p.3).

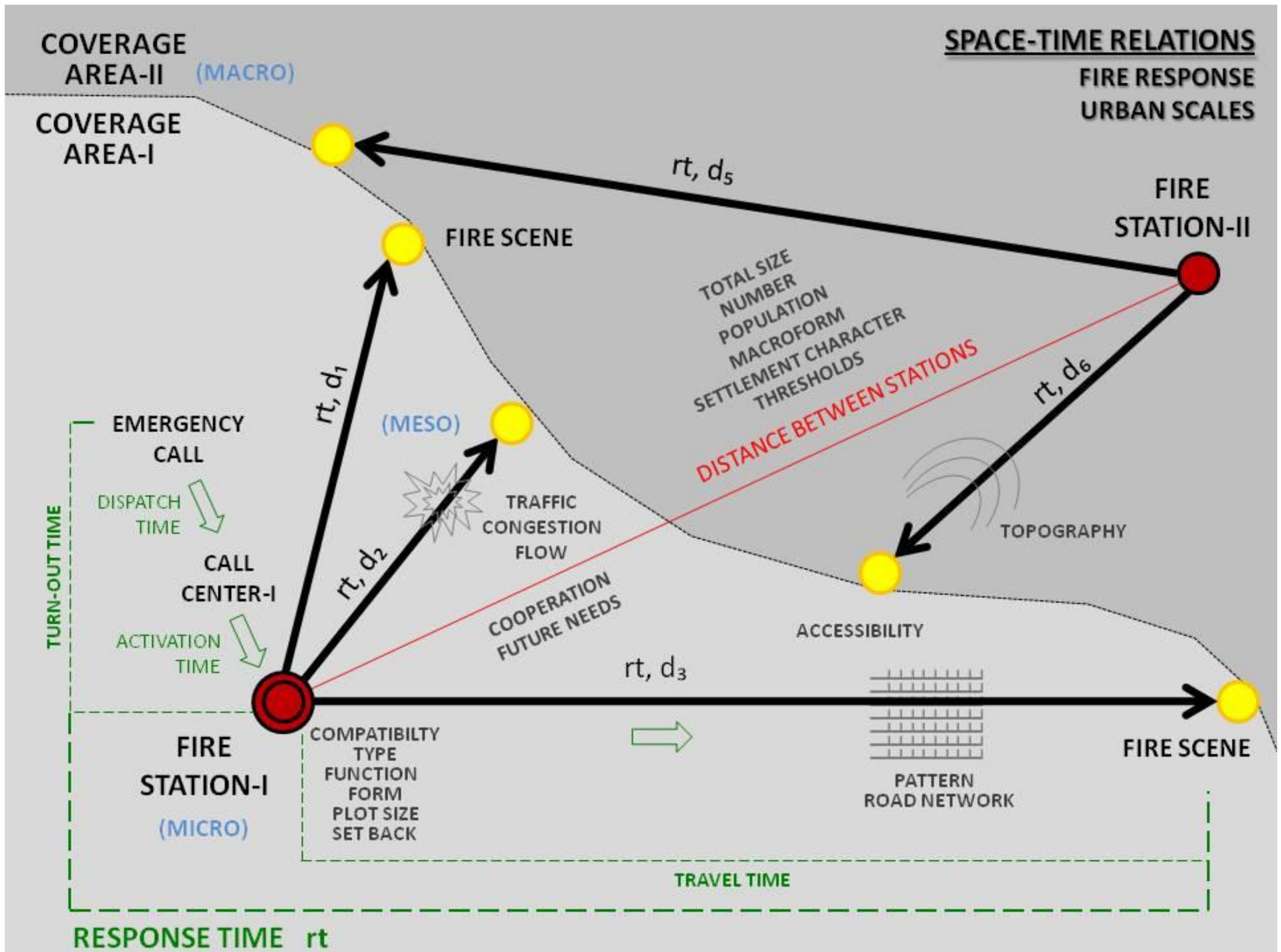


**Figure 2-2** Fire Station - Response Time - Coverage Area Relations

## 2.2. Site Selection and Design Criteria of Fire Stations

In this chapter, information from the literature review is evaluated in order to define the key points of site selection and design criteria of fire stations. Criteria are presented under the size and location headings, which are the most important indicators to be defined in this problem. In addition, other indicators of fire stations' spatial requirements are explained. Defined criteria are classified according to urban scales, in order to prepare a practical base for the suggested legal improvements as well as presenting assistance to urban designers and decision makers about the site selection and spatial implementation of fire stations.

Spatial requirements of fire stations in urban areas are clarified according to various indicators. According to FEMA (1997, p.9), the department administration or governing authority, the building committee and the design team should focus on the needs assessment model to determine department requirements and to identify potential hazards and safety concerns in selecting the site and designing the station.

FEMA (1997, p.19) who states that the building of a station may be an infrequent event, requiring new research each time due to changing topography, demographics, and industrial developments, determines the indicators in the process of station design that is started by the following steps:

- Determination of fire/EMS department and city needs;
- Determination of project constraints (location and safety/health restrictions);
- Development of the preliminary station layout.

The American Insurance Association (AIA) defines some of the factors that should be considered when planning and constructing new stations including (FEMA, 1997, pp.25-26):

- response time,

- area of response coverage,
- ability to concentrate department resources.

Moreover, site selection should accommodate:

- station areas for future growth or storage,
- locating fuel sites in the event of disasters,
- emergency power needs in the event of prolonged power outages,
- apparatus response in more than two directions,
- ample parking for personnel working at the facility,
- training needs,
- communications considerations (including line-of-sight), and
- station distance from the curb to avoid potential pedestrian or vehicular accidents.

When developing a new site for emergency response stations, main equipment which is one pumper engine, one tanker, one brush truck, one ambulance and one ladder truck for each building should be provided. Make up of units will depend on the criteria as seen below (Spotsylvania County, 2009, pp.13-19):

- the location in the county,
- density and
- target hazards within those respective areas

According to Mahmud and Indriasari (2009, p.93), a series of suitability criteria should be evaluated to determine suitable sites for locating new fire stations such as:

- proximity to high-hierarchy road
- distance to existing fire stations
- ability to cover fire risk zones
- proximity to water sources

According to Habibi et. al. (2008, p. 3308), the main criteria for fire station location are seen below:

- distance among the stations
- level of fire risk in the different parts of a city
- accessibility
- the coverage area
- population
- the size of plot
- the directions of city expansion

The location of fire and rescue stations is determined under a number of factors in detail by Queensland Government (2007, p.94):

- response time profile,
- the current and projected population;
- planned future development and the urban footprint;
- a hazard assessment and associated risk assessment;
- the proposed road network;
- fire levy forecasting;
- incident profile of the area;
- the type of community (urban, rural, isolated);
- the number incidents per day (demand);
- demographic of the community;
- accessibility to (and egress from) road networks;
- response time profiling and risk profiling of the community;
- proximity to existing fire and rescue stations.

As presented in the example of Seattle Fire Department’s siting study for Fire Station-20, an un-ranked long list of 42 potential sites is constituted according to seven basic site selection criteria such as size, grade, and proximity to arterials and the key area conditions such as density and future growth and environmentally critical areas (Appendix-XI). By means of assessment according to these indicators, 42 potential sites reduced to 4 candidate sites (EnviroIssues and Juan, 2008, p.1).

Briefly, size and location are the most important indicators for site selecting and designing of a fire station in urban areas. It is necessary to define a preliminary total size of fire station areas in a city by considering future requirements. Then the total area is divided and distributed according to the related location criteria.

### 2.2.1. Size

The size of fire station is defined in two separate meanings. One of them, total cumulative size of all fire stations per person in an urban area consistent with the literature is presented in Table 2-1. Other meaning defines size as the plot size of an individual fire station is presented in the Table 2-2. Total size of fire stations is usually determined according to the population that will be under coverage.

In the current development law, criteria of required total size of Urban Administrative Area depend on the total population of the considered urban area. Fire station areas are allocated in these urban administrative areas. However, required total area size of the fire stations should be considered in particular to the fire stations according to the population. According to Table 2-1, area of fire stations per person varies from 0,01 to 0,10 square meter per person. For metropolis, total fire station are is 0,03 square meter per person which is suggested by Brandt.

**Table 2-1** Fire Stations' Total Area according to Population under the Coverage

| **Reference** | **Area of Fire Stations per Person** | **Population relations** |
|---|---|---|
| in Germany (Ersoy, 1994, p.181) | 0,05 to 0,10 $m^2$ per person | |
| (Habibi etal., 2008, p.3308) | 0,02 to 0,06 $m^2$ per person | For 50,000 people |
| (Ersoy and Eker cited Önen,Ü; 1980, p.192) | 0,06 $m^2$ per person (according to Recherberg) | For 50,000 people |
| | 0,01 $m^2$ per person (according to Arckerle) | |
| | 0,01 $m^2$ per person (according to Pohl) | For 30,000 people |
| | 0,03 $m^2$ per person (according to Brandt) | For metropolis |

The standard of square meter per person provided in the current development law in Turkey is valid for all administrative areas but not specific to fire station areas as given in Appendix IV. When the ratio of total fire station area given in the literature, to the total administrative area defined in the legislation is evaluated, it is found that approximately 0,6per cent of the administrative area is allocated for fire stations in Turkey. When this calculation is adopted to the BIMTAS' (Istanbul Metropolitan Municipality Engineering and Consultancy Services Cooperation) proposed standard(2003, p.175) for a minimum total size of Urban Administrative Areas which is presented in the literature review chapter is 1,40 square meter per person, the minimum percentage is approximately up to 0,5 per cent.

Another concept in the scope of size is the plot size of fire stations. It is observed in the reviewed literature given Table 2-2 that the minimum plot size should be at least 1000 square meters. On the other hand, maximum plot size can be up to 20000 square meters which depends on the variety of services that will take place in the station such as communication centre or exercise yard.

**Table 2-2** Plot Area and Station Type

<table>
<tr><th>Reference</th><th>Plot Area and Station Type</th><th>Station Type</th></tr>
<tr><td>(in Germany, 2_17G p.181; Ersoy, 2009)</td><td>6.000 to 8.000 m$^2$</td><td>-</td></tr>
<tr><td rowspan="4">(Habibi et al., 2008, p.3308)</td><td>Minimum 1000 m$^2$<br>(concentrated area of the city)</td><td>All sizes</td></tr>
<tr><td>1500 to 3000 m$^2$</td><td>Small size</td></tr>
<tr><td>1000 to 3000 m$^2$</td><td>Medium size</td></tr>
<tr><td>6000 m$^2$</td><td>Large station for more than 7.500.000 people</td></tr>
<tr><td>(Spotsylvania County, 2009, pp.13-19)</td><td>Minimum ~1400 m$^2$</td><td>Building size</td></tr>
<tr><td rowspan="3">(Queesland Government, 2007, p.2)</td><td>3000 to 4000 m$^2$</td><td>Auxiliary station</td></tr>
<tr><td>3000 to 6000 m$^2$</td><td>Permanent station</td></tr>
<tr><td>10000 to 20000 m$^2$</td><td>Permanent station with specialist facilities attached, e.g. workshops and communication centre</td></tr>
<tr><td>(EnviroIssues and Juan, 2008, p.6)</td><td>~1300 to ~1900 m$^2$</td><td>Minimum site requirement</td></tr>
</table>

Size of fire stations is defined according to variable issues such as population or population groups, settlement characteristics, types of fire stations, equipment, staff, and vehicles within the fire stations.

According to Neufert (2000, p.452) a fire station can act as emergency medical communication centre as well as district or regional control centre in the event of a large-scale emergency. Also space requirements should take into consideration the size of the lot, the anticipated use of the structure for other municipal functions, and other possible use for best utilization of the structure (FEMA, 1997, p.26).

As presented in the example of Seattle Fire Department's siting study for Fire Station-20, approximately 15,000 square feet (approximately 1400 square meters) is needed to accommodate the full program of fire service (EnviroIssues and Juan, 2008, p.6).

The size of a fire station area is determined considering the character of coverage area located within. The areas for the stations in the urbanized area are somewhat smaller than those in the more rural portions of the district. This again is according to residential density and commercial intensity. There are differences in station design whether the facility is in a metropolitan area or a rural area, whether fully staffed by paid personnel or partially staffed by volunteers, and whether headquarters or substation or having specialized functions. Some aspects of station design are also affected by the overall response level as some stations are required to do multiple runs in the immediate local area of the community, while other stations may have infrequent demand but cover relatively larger areas (FEMA, 1997, p.22).

The main dimensional components of a fire station are size of area/building lot and length of facade. Additionally, size of a fire station is also dependent on the levels of staffing, equipment and vehicles. Required fire station area can also be estimated by summing up the partial area sizes of all architectural units of a fire station. Therefore number of personnel, vehicles and equipment; types of services and functions within a fire station are the factors used for determining architectural units of a fire station.

Key safety and health concern for these functions are often related to the number of people that the facility must accommodate. Staffing levels and number of personnel on duty are important. Furthermore the total number of people that can be in the facility at any one time, due to training, a disaster, or community event, should be considered (FEMA, 1997, p.21).

Ersoy states (2009, p.154; 1994, p.194; Ersoy and Eker, 1980, p.191) that 23 vehicles are required per 2.000-5.000 residents. Another staffing standard requires minimum 12 firefighters for population of 20.000-60.000 people and minimum 18 firefighters for population more than 60.000 people in Germany (Ersoy, 1994, p.181; Ersoy, 2009, p.145).

Basically, as in the example of Singapore, each fire station should be equipped with at least one fire engine, one Red Rhino light fire attack vehicle, and one ambulance (Liu et al., 2006, p.364), so that determination of the station area is also influenced accordingly.

The facade length as presented in the example of Seattle Fire Department's siting study for Fire Station-20, the ideal dimensions of plot 120 feet (36.6 meter) by 130 feet (39.6 meter) (EnviroIssues and Juan, 2008, p.3).

### 2.2.2. Location

Fire stations offer the necessary personnel and equipment for saving life and property during a fire accident and are inevitable components of any infrastructure environment. While it is imperative that fire stations are properly situated, their access to transportation routes and their promptness in offering services are also of considerable importance. Fire stations must not only be located such that maximum area may be served, but also strategically placed so as to minimize the response times to fire scenes (Liu et al., 2006, p.361).

Usually, the facility differences relate to the size of the fire fighting apparatus as well as facility location. For example, aircraft rescue fire fighting (ARFF) stations which provide fire protection to flight lines and aircraft, are located adjacent to the runways on airport property. Similarly, stations with hazardous waste response teams are located near likely spill sites, or high risk land use (Mion, 2009, p.1).

The most effective site selection indicator of fire stations is the relation between response time and coverage area concepts. Criteria among the response time and coverage area are presented in Table 2-3 and are evaluated in the following sections.

**Table 2-3**Coverage Area-Response Time Relations and the Other Indicators

| REFERENCE | RESPONSE RADIUS OF COVERAGE AREA (km) | RESPONSE TIME (min.) | OTHER INDICATORS |
|---|---|---|---|
| (Habibi et al., 2008, p.3307) | 2 km | 3-5 min. | Distance Between Two Stations 2500 m. |
| (Ministry of Public Security, China, 2006) | ~1,2 – ~1,5 km | 5 min. | |
| (Spotsylvania County, 2009, pp.13-19) | ~4,8 km | 6 min. | Urban or Suburban Areas (inside the Primary Development Boundary) |
| (Wu and Ren, 2009, p.779) | ~1,2 – ~1,5 km | 5-8 min. | For Very High & High Fire Rate Category Areas (China) |
| (Erkut et al., 2001, p.2) | – | 9 min. (a widely accepted standard for EMS response ) 5 min. (the goal of the city) | - Demand Points<br>- Fire Station Locations<br>- Travel Distances |
| (Liu et al., 2006, p.361) | ~0,5 km – ~8,5 km | 5 min. (proposal of Local authorities) | Distance Between Nearest Stations 1 to 9 km |
| (EnviroIssues et. al., 2008, p.3). | – | 4-6 min. (ideal RT) | - Travel Speed<br>- Traffic Volume |
| Balamir (1966, pp.23-25) | 1,2 - 4,8 | 5-8 min. | According to Risk Classes |

#### 2.2.2.1.Response Time

Response time is considered in evaluating and selecting appropriate sites for fire stations. Better location selections ensure the targeted response goals being met (Spotsylvania County, 2009, pp.13-19).

According to Erkut et al. (2001, p.2), the reasons of the deterioration in the quality of the service in the future are firstly the growing of the city's population. Secondly, the demand for fire response increases. Accordingly, the response time increases.

Targeted response time values can be chosen different than 5 minutes according to the settlement character of the considered area. If the fire station is operating mainly in conservation areas with timbered buildings or high rise and densely populated residential areas with a very high risk of fire, the response time should be lower than 5 minutes.

Habibi et al (2008, p.3308) suggested a response time of 3 minutes to 5 minutes considering the population density and land uses. However, if a fire station is operating in a medium risk category area, Wu and Ren (2009, p.779) suggested a response time of 12 minutes still acceptable. Therefore due the variety of response time depending on the different urban characteristics, targeted response time should be determined according to on site evaluation.

As a result of the literature survey as summarized in Table 2-3, it is observed that an average response time lower than 5 minutes can be accepted as a targeted response time goal for urban fire stations. In order to lower the response time, distance between fire stations should be lower.

Choices of routes are preferred to ensure flexibility for fire response in respect of both time and space in case of being closed each of them. Flexible solutions can be provided by spatial design with the help of gridal pattern. Therefore urban pattern has an impact on locating fire stations, for instance in a gridal urban pattern response time reduces. In such urban tissues, distance between fire stations can be increased as well as ensuring desired response time limits.

On the other hand, maintaining the desired average response time is not the single goal to be targeted. Fire station's service level in the responsibility area should be considered and, coverage area should be maximised ensuring the desired response time in every incident.

#### 2.2.2.2.Coverage Area

Coverage area can be determined considering the indicators such as targeted response radius, distance between the fire stations, the number of annual emergency calls, risk levels and population of the area and type of the station, urban thresholds.

As an example, The Fire and Rescue Commission of Spotsylvania County (2009, p. 17) recommends establishing new service areas based on response time standards resulting in smaller service areas for the fire/rescue stations located within the Primary Development Boundary in which public utilities are provided and development is discouraged outside.

Current boundaries of coverage areas should be examined and revised if necessary, in order to reach the desired response time targets. Accordingly, current fire station area can be enlarged, fire station can be relocated or new fire stations can be located with the aim of ensuring the satisfactory fire service. Existing and potential fire station locations should be identified that the areas of the city not covered by the existing stations within the desired time limit at present and after the additional coverage projected (Erkut et al., 2001, p.2).

It is suggested that, fire station's responsibility area should be reduced for the stations receiving more than 1500 emergency calls annually. The response area radius for these stations should be reduced to 3 miles (4.8 km) in order to decrease response times (Spotsylvania County, 2009, p.13-19) as given in the Table 2-3.

In addition, according to Liu et al. (2006, p.363) distance between two neighbouring stations should be 1 to 9 km. As an example of determining the coverage area, population per a fire station values are given in Table 2-4. According to this table, aiming to provide satisfactory fire response service as well as the optimal usage of limited public resources; the population of coverage area for one fire station can vary from 1000 to 50000 people.

**Table 2-4** The Relations among Area, Population and Number of Fire Stations

| **Reference** | **Number of Fire Stations per Population** |
|---|---|
| (in France, 2_TGE p.179; Ersoy, 2009, pp.144-159) 145 | 1 Fire Station/25.000 people (Minimum)<br>1 Fire Station/40.000 people (Maximum) |
| (in Portugal, 2_33TG_p.180) | 1 Fire Station/1000 people |
| (in Germany, 2_17G p.181; Ersoy, 2009) | 1 Fire Station/ 2.000-10.000 people |
| (Habibi et al., 2008, p.3307) | At least 1 Fire Station/50.000 people |
| (Queensland Government, 2007, p.2) | 1 Fire Station/25.000 people |

Another indicator of determining the coverage area is the number of emergency calls received annually. It is suggested by the Fire and Rescue Commission of Spotsylvania County in USA (2009, p. 17) that, fire station receiving emergency calls more than 1500 per year should reduce its responsible coverage area.

According to the Report of Proposals for Urban Public Services by BIMTAS (2003, p.175), all of the fire stations have 2nd order and 3rd order responsibility areas to support the primarily responsible fire station.

The primary objective in locating fire stations is to identify which geographical placement of stations will provide coverage to the greatest percentage of population and area, with the least amount of overlapping of service areas in order to provide optimal usage of limited public resources (Hilton Head Island, 2004, p.7).

### 2.2.3. Other Indicators Effecting Size and Location Decisions

Accessibility, future needs and extensions, cooperation with the other emergency management services, compatibility with adjacent landuse and thresholds are other indicators influencing the location and design decisions of fire stations.

#### 2.2.3.1.Accessibility

Accessibility should be taken into account in emergency facility location problem to improve emergency services (Mahmud and Indriasari, 2009, p.92). Increased accessibility reduces response time significantly. In order to provide accessibility, fire stations should not be located over restricted transit roads, such as motorways, tunnels etc. If it is necessary to locate the station over a restricted transit road, junction points should be preferred, allowing access to all directions. Similarly, according to Neufert (2003, p.452) locating a fire station linked to a motorway is advantageous in terms of accessibility. Furthermore locating a fire station near a controlled and signalised junction will provide access to all directions with the control of traffic signalisation by call/dispatch centre or with the help of electronic devices of fire engines in case of an emergency. As suggested by FEMA (1997, p.23) response functions should be tied into local traffic lights.

It is also recommended to locate stations at points with quick access to a major arterial if possible sites should be located near two major arterials that offer both east/west and north/south travel (Spotsylvania County, 2009, pp.13-19). Similarly, it is stated by Queensland Government (2007, p.94) that facilities must be designed and located for safe, efficient and direct access to streets, including major traffic routes, and include an alternative exit route.

Fire stations should have direct and quick access to the arterial roads with more than 22 m. width or sub arterial roads to avoid any traffic congestion (Habibi et al., 2008, p.3307). Therefore, siting a fire station on a very busy arterial with travel speeds in excess of 40-45 mph (approximately 65-70 km per hour) is highly undesirable (EnviroIssues et. al., 2008, p.3).

Adjacent roads or junctions with high density traffic flow negatively effects the response time of the station and such locations should not be chosen for the fire stations. According to Tunç (2003, p.398), the capacity of a road or a junction is defined as its level of service or its ability to serve. There are six Levels of Service defined in the Highway Capacity Manual (2000) which is given in Table 2-5.

**Table 2-5** Level of Service

| Level of Service | Description | Average Control Delay (seconds/vehicle) | |
|---|---|---|---|
| | | **Signalized Intersections** | **Unsignalized Intersections** |
| **A** | Represents free flow. Individual users are virtually unaffected by others in the traffic stream. | ≤ 10.0 | ≤10.0 |
| **B** | Stable flow, but the presence of other users in the traffic stream begins to be noticeable | 10.1 – 20.0 | 10.1 – 15.0 |
| **C** | Stable flow, but the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. | 20.1 – 35.0 | 15.1 – 25.0 |
| **D** | Represents high-density, but stable flow. | 35.1 – 55.0 | 25.1 – 35.0 |
| **E** | Represents operating conditions at or near the capacity level. | 55.1 – 80.0 | 35.1 – 50.0 |
| **F** | Represents forced or breakdown flow. | > 80.0 | > 50.0 |

**Reference:** Highway Capacity Manual, Transportation Research Board, 2000, pp. 5-6

Fire stations should not be located near the roads or junctions of which levels of service will be between C and F within a planning term. Fire stations located near junctions or roads having a level of service between C and F will suffer from dramatic increase in response time caused by the lagging fire engines in traffic jam.

The station should not locate in the corner or adjacent to the crossroads which there are traffic congestions. To have a better response, the stations should not be sited in one sided or parallel routes, as the lack of connectivity in local and one sided streets decreases the access of the stations (Habibi et al., 2008, p.3309) Provide alternative access points to a fire station site.

Another concept effecting the decisions regarding fire station's location is the form of the plot. Corner plot can be chosen, allowing easy entrance and exit with at least two alternative plans. Entrances for apparatus bay and private car parking should be designed separately as given in the examples of Waterford Headquarters and Southfield Fire Stations in Appendix-III. Plot should also allow the station having direct access to maximum available directions. An example sketches of a Fire Station zoning process is given as in the Appendix-I.

According to Collins (2000), in the National Symposium on Fire Station Design, one of the presentations about station location and site selection issues, by Sally Young of the Charlotte Fire Department and Kevin Roche of the Phoenix Fire Department, included important issues such as;

- placing stations mid-block (having two facades to the roads) on side streets where entering the street is easier
- entering the major street from the side street is facilitated by traffic signals controlled from the station, apparatus or dispatch centre

[http://firechief.com/mag/firefighting_premiere_stationdesign_conference, retrieved on 09.07.2010]

The example of end-block (having three facades to the roads) location is given in Figure 2-3 and the example of mid-block location in Figure 2-4. Locations of apparatus room, office and parking area can be seen in the detailed zonings. Additionally, direct access from apparatus room to arterial/collector streets, alternative entry-exit points, a setback distance and a buffer are provided for both of the examples.

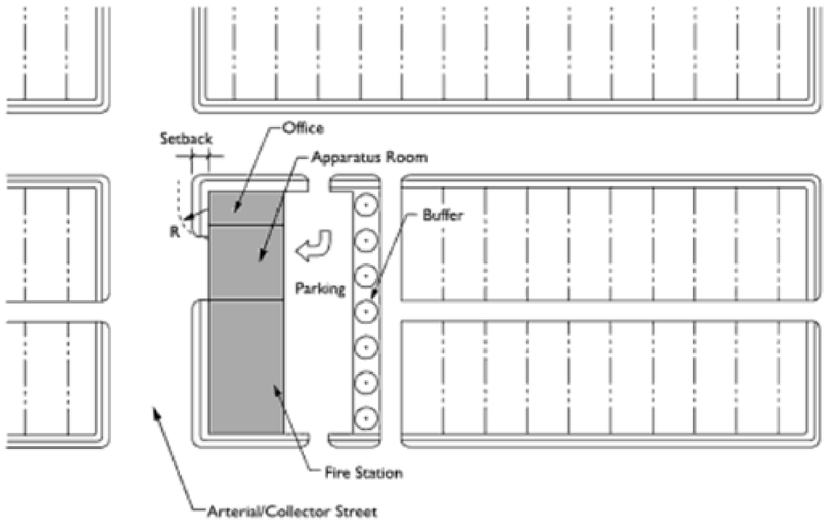


**Figure 2-3 End Block Location, One-Storey Station**

(American Planning Association-APA, 2006, p. 206)

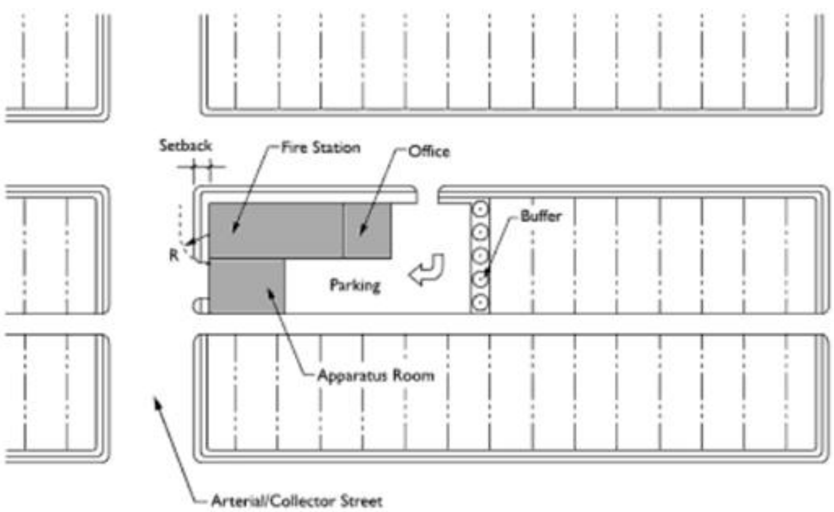


**Figure 2-4 Mid-Block Location, One-Storey Station**

(American Planning Association-APA, 2006, p. 206)

Relatively flatter land location to allow for safe manoeuvrability on site and adjacent streets, to avoid vehicle structural stress, and for timely operation of apparatus and equipment should be required (EnviroIssues et. al., 2008, p.13). Topography of the site is similarly mentioned by Habibi et al. (2008, p.3308) that flatter topography of site would be beneficial. There should not be car parking on the street on which the entrance of the station also located.

Complying with the American Disabilities Act (ADA) as fire stations are public buildings and often times used as polling places. This may require the use of ramps or lifts depending on the configuration of the facility (FEMA, 1997, p.32). Accessing with various modes of public travel to the fire station should be considered for public interaction through using community room of fire station, attending workshops or educational organisations.

#### 2.2.3.2.Ensuring Future Needs and Extensions

As mentioned by Charlotte Fire Department Chief, both the short and long-term impact of the location and lot size should be considered in the design phases. Furthermore, the proposed fire station should also be designed and located so as to accommodate the future demands and extensions which may develop in the surrounding area (Kevin Roche and Sally Young; District of Columbia Fire Department, 2006, p.6) [http://66.161.236.145:8000/msa_ifyoubuildit0707.pdf, retrieved on 09.07.2010].

Moreover, District of Columbia Fire Department (2006, p.6) cited in their manual that fire stations are a critical part of the community and are essential to maintaining public safety. For this reason, they should be designed for an extended useful service life.

Changing requirements of facilities with time can occur as response needs change or as department functions are added or deleted. What is often built to meet the department's current needs requires periodic re-evaluation and possible upgrading to meet the demands of the future. As the fire and emergency medical services grow and expand, new facilities are needed for specialized training or testing of equipment (FEMA, 1997, p.23). There should be at least three or more apparatus bay stations built to accommodate reserve apparatus, emergency medical units to promote future growth.

Habibi (2008, p.19) states that fire stations should not be placed in unsuitable locations by means of the future expansion. Considering the flexibility of the fire and EMS stations, several questions should be examined (FEMA, 1997, p.19-20);

- Can the station be used for other municipal functions?
- Can department needs be met with shared facilities?
- How long should these facilities last?
- What are the most cost effective ways to build these facilities?
- What should be the size and spacing of stations?

#### 2.2.3.3.Cooperation

Fire stations, which serve districts, are in contact with accident and emergency medical departments (Neufert, 2003, p.452). Emergency service facilities are dispatching points for fire fighting equipment, ambulances, police, or other emergency vehicles (Chrissis, 1980, p.63). Therefore, cooperation between the neighbouring fire stations and other emergency services such as Emergency Medical Service and Police should also be considered in the location of the fire stations. According to Zlatanova (2008, p.1632), fire stations, para-medical teams, municipalities and police are the first responders in the management of emergencies. Moreover, fire stations should be in proximity to emergency services.

FEMA states (1997, p.21), the design of fire and emergency medical service stations have changed over the past decades. They are being recognized more and more as specialized facilities with their own specific design approaches. Design and facility features differ among fire stations, EMS (Emergency Medical Service) stations, and other types of facilities based on a variety of factors, including the role of the station, the type of department and expected response level, specific functions of the facility, integration with joint or shared facilities, community restrictions, future requirements, and available resources. These same factors also can impact the level of safety and health for personnel working and living at these stations.

According to Geis (2000, p.16), it is essential for ensuring a disaster resistant community to analyse and plan for the community support systems including the considerations of clustering service and functional uses for example, combining fire, police, health, and administrative functions.

#### 2.2.3.4.Compatibility with Adjacent Land Use

Compatibility of fire stations with the adjacent land use should be considered in site selection. Fire stations should be located away from the educational facility areas in order to avoid safety problems, interruptions on educational activities or undesired behaviours through interaction of students (Kayhan and Eroğlu, 2002, p.12). Distance between the fire station and nearest educational area or land use should be determined ensuring the desired safety and comfort.

As an example, there is a Special Uses Zone defined within the scope of Development Plan consolidated at 24 July 2008 by the Government of South Australia as a zone accommodating special public and private activities of an institutional or open character. Fire Stations are mentioned as one of the developments being non-complying in the Special Uses Zone (Government of South Australia, Development Plan consolidated at 24 July 2008, p.134).

It is necessary to allocate specific plot of land for the rescue near the stations in the case of any incident and in usual time can be used as green space (Habibi et al., 2008, p.3309). However, the new selected sites should not locate in adjacent with preventive factors like gardens, agricultural lands, hills and so on, as it decreases the quality of station response (Habibi et al., 2008, p.3308)

One of the design criteria should be considered when developing a new site for emergency response stations is to co-locate fire and rescue facilities for maximum efficiency with other public facilities as well. Consider including a training room for 50-100 people in the design of new fire/rescue facilities unless there is a similar public facility available for the surrounding community.

Another recommendation regarding the location and design decisions of fire stations is to minimise the possible negative impacts such as headlights, sirens, truck noise emergency lighting, to existing structures, residential uses, and historical sites (EnviroIssues et al., 2008, p.3). Commonly, facilities are required to shield neighbouring structures from noise by use of shrubbery (FEMA, 1997, p.23).

EnviroIssues et al. (2008, p.17) states within the scope of Fire Station 20’s siting study that, access to a busy major arterial from the current location of station allows responding vehicles to attain arterial speeds before merging with the on-coming traffic. A location directly on a busy major arterial would create frequent, irregular interruptions in traffic flow as slow moving fire vehicles cross and or enter the traffic flow.

Similarly, some of the land uses are more hazardous and impose a huge loss of life and financial resources and have a potential of quick flashover such as gas stations, warehouses, industrial areas (Habibi et al., 2008, p.3309). Demand for services can also be impacted by the occurrence of these areas and also high risk industry.

#### 2.2.3.5.Thresholds

Considering thresholds is one of the main factors influencing the location decision of fire stations. Geographical thresholds can cause increasing the number of required fire stations. As in the example of Istanbul, there are 4 fire stations in Adalar District where four island settlements take place.

Fire stations should be located on or close to main arterials, but outside of areas that experience high volumes of traffic congestion, as well as disruption caused by railway lines (EnviroIssues et al., 2008, p.3).

Topography should be taken into account in site selection of fire stations because response time increases significantly in the urban areas having high slope in the streets more than10 per cent grade. Furthermore, according to experiments carried out by Bianchini et al., (2005, p.248) it is observed that increase in inclination of the terrain increases the propagation speed. Thus, distance between stations should be decreased when there exists topographical thresholds.

Environmentally critical areas are not also preferred to locate a fire station. Engineering and construction techniques can help mediate the issues associated with building in a liquefaction zone, but it is cost prohibitive. Although it is technically feasible to build a facility to withstand earthquakes, the streets themselves in a liquefaction zone will be significantly damaged in a major seismic event, preventing apparatus from getting to an emergency. Leaving the station area and serving as many locations as possible following an earthquake led to a siting requirement that stations be located away from liquefaction wherever possible (EnviroIssues et. al., 2008, p.7).

The other important issue is related to fires occurring after earthquakes. According to Gallion and Eisner (1986, p.412), ground shaking and faulting are not the only hazards connected with earthquakes. Landslides, flooding, and fires that can follow a quake often cause more damage than the quake itself. Therefore, designing for the changing nature of settlement pattern especially road network after disaster such as earthquakes should be considered.

If the area faces several geographic conditions as well as land use changes, it must be considered in site selection of a fire station. Access from the fire station site to the any portion of the response area could not be limited if a major earth event occurred. The property should be situated to minimize the potential risk that the station will be prevented from responding to its service area by pavement buckling, bridge failures or other destruction of transportation routes following a seismic event or other natural disaster and also a district with a second station should be provided to assist another station in case of a major earth event or emergency (EnviroIssues et al., 2008, p.3).

## 2.3. Classification of Criteria According to the Urban Scales

In this section, criteria of site selection and design of fire stations are classified, and concepts of urban scales regarding fire response are explained. Classification of the site selection and design criteria according to the urban scales is very important because it provides a basis towards the implementation of the recommendations resulted in this research. It is important because, the relations between these criteria and the official plans are established by using the standard scales of planning in 1/25000, 1/5000 and 1/1000 scales, corresponding to macro, meso and micro scales respectively.

### 2.3.1. The Concept of Urban Scales within the Scope of Fire Response

According to Günay (1999, p.32), in order to achieve the integration of “urban” and “design” or in other words “planning” and “architecture”, urban design should become a part of public policies of urban development control. In this chapter, urban scales within the scope of urban design are reviewed in order to constitute a basis for regulations by classifying spatial requirements according to urban scales.

One of the definitions of urban design is explained as the theory and practice of producing the form and life of the city in the macro, meso and micro scales. Another important definition of urban design is also stated by Günay (1999, p.32) as sometimes designing and making, more extensively guiding the design and making of the city and its parts.

According to Geis (2000, p.4), for a community to keep its natural hazards from becoming human disasters, it must be at least as concerned with the overall workings - functioning, connections/relationships, service/use, capacity, and size/scale-of all its systems and components, as it is of the structural integrity of its buildings and the effectiveness of its land use plan. Similarly, these systems and components are also the subject of spaces regarding fire response.

Spatial options to improve the quality of fire services which are stated by Mahmud et.al (2009, p.87) are adapted according to urban scales as presented in the **Error! Reference ource not found.**.

**Table 2-6** Spatial Relations of Options to Improve the Quality of Fire Service

| **Spatial Relations** | **Urban Scales** | **Options** |
|---|---|---|
| Direct | Macro Scale | Propose a new fire station/EMS station |
| | Meso Scale | Re-location of the existing station |
| | Micro Scale | Propose an extension of the existing station, an addition of a new fire hall to the existing station |

One of the purposes of city plans is to attain a safer urban environment for the population. This safety purpose also includes the fire safety measurements at urban scales (Sarikaya, 2001, p.151).

#### 2.3.1.1.Macro Scale

Günay (1999, p.33) states by referring to Lynch, Rodwin and Spreiregen; at the macro scale urban design is conceived as an integral part of the decision making process of urban macroform.

According to Kaygısız (2008, p.33), the concepts, critic distance and critic time, have an effect on determining urban macroform besides the vertical and horizontal relations between services and people. The evaluation models on determining the fire company's response time presented by Wu and Ren (2009, p.783) and summarized in Appendix-II which will supply the fire protection planning of newly built areas with scientific decision-making support, and help the built-up area to reasonably allocate the fire defence force in a way that will match its risk.

Progressively, cities are planning an expansion and new developments have been approved. This increases risk and the total area that has to be covered as well as the population. Consequently, the deterioration emerges in the quality of the fire services in the future (Erkut et al., 2001, p.3). Planning the public services in development areas to ensure fire response facilities should be one of the factors to define the urban macroform. This is important considering the extent of the cities in Turkey which are expanding steadily, especially in metropolises that are densely populated.

Considering future spatial requirements of fire stations, it is stated as the issue of an urban macro scale that land for stations is often purchased two to three years in advance, occasionally outside existing city boundaries or urban fringe [http://firechief.com/mag/

firefighting_premiere_stationdesign_conference, retrieved on 03.06.2010]. Facility location models concern the provision of a service to satisfy a spatially dispersed demand. A demand for the service exists at a large number of widely dispersed sites. Therefore, for reasons of cost, the service must be provided from a few, centralized locations (Mahmud and Indriasari, 2009, p.88).

It is necessary that the pattern of physical expansion of the city should be studied exactly and the new fire stations should be established by the increase of population in the next 10-20 years and future building density. The final development pattern of the city should be considered for the new fire station location planning within a rational vision by being based on standards, spatial criteria or mathematical models (Appendix II). It is necessary to allocate plots for future fire stations in the high density areas due to population increase (Habibi et al., 2008, p.3308). As well, mutual aid agreements exist with surrounding municipalities to provide back-up services to their forces, as needed (Erkut et. al., 2001, p.3).

Consequently, within the perspective of fire response issues, roughly total size of fire stations' areas in a city should be found and the outer boundaries of the response zones overlapping with the city macroform should be determined in macro scale.

#### 2.3.1.2.Meso Scale

Günay (1999, p.33) states; the concepts of image and character developed at the macro scale were further consolidated at the meso scale and have become important inputs in the design of the environment beside functional criteria. In this connection, parts of the city; districts, neighbourhoods, centre, green systems, development corridors, regeneration in built-up areas are all subject matters of urban design at the meso scale. Moreover, these functional areas inhabiting industry, small production, storage and road system, that is, the veins of the city which those approaching urban design from aesthetical, visual or symbolic values do not consider worth designing are all basic issues of urban design.

EnviroIssues et al. (2008, p.3) suggested to be considered how a new fire station location would impact the future goals, uses, and urban design potential for the study area. Safety and emergency response are being given greater importance while planning infrastructure and transportation projects. Accordingly, the number and location of fire stations significantly influence the efficiency of emergency response during fire accidents (Liu et al., 2006, p.361). Similarly, FEMA(1997, p.11) states that the location of the structure in consideration to the community's growth and response time plus the enhancement of total coverage with existing or neighbouring stations is a paramount feature in new station's design.

Thus, after determining total size of fire stations' areas and the general outer boundary of the response zones within macro scale, distribution and location of fire stations should be decided within the meso scale according to the city character, road network and traffic flow, attributes of the response zones and risk groups considering the parts of the city. Cooperation between other emergency response services and thresholds influencing design are also within the scope of urban meso scale.

#### 2.3.1.3.Micro Scale

According to Collins (cited in Sally and Young, 2000, p.1) the selection of the physical location of a fire station is one of the earliest and most important phases of the fire station construction process. Within the scope of urban micro scale, the physical and functional parameters of fire station plot such as size of a fire station area, its plot form and location, compatibility with adjacent landuse, entry-exit points, minimum facade length, manoeuvring area and set-back distances are discussed.

It should also be noticed as emphasized by Günay (1999, p.34) that the small scale are of utmost important, but it is the planning or design decisions at the larger scales which would determine and hold together such decisions.

### 2.3.2. Classification

The importance of criteria classification according to the urban macro, meso and micro scales is being provided as a basis towards to implementation presented in Appendix XII. The spatial requirements within the macro scales which are related to the indicators such as size, response time, coverage area, accessibility, future needs and extensions, cooperation and thresholds are presented that;

- Fire stations' area per person varies from 0,01 to 0,10 square meter per person, with a suggested value of 0,03 square meters for metropolis,
- When the ratio of total fire station area given in the literature, to the total administrative area defined in the legislation is evaluated, it is found that minimum0,6 per cent of the administrative area can be allocated for fire stations in Turkey having a population more than 100.000,
- Average response time lower than 5 minutes can be accepted as a targeted response time goal for urban fire stations. In order to lower the response time, distance between fire stations should be lower spatially.
- Targeted response time values can be chosen different than 5 minutes according to the coverage area character and the risk groups within it.
- Urban pattern can have an impact on locating fire stations, for instance in a gridal urban pattern response time reduces. In such urban tissues, distance between fire stations can be increased as well as ensuring desired response time limits.
- Suggested distance between nearest stations should be between 1 and 9 km considering economical and safety issues,

- 25000 people under the coverage of a fire station are accepted as a reasonable population considering the optimal usage of restricted public resources (LR:2000-40000 people)
- Fire station receiving emergency calls more than 1500 per year should reduce its responsible coverage area
- Locating stations which provide coverage to the greatest percentage of population and area, with the least amount of overlapping of service areas in order to provide optimal usage of limited public resources
- Fire stations should not be located over restricted transit roads, such as motorways, tunnels etc.
- Planning for any potential expansion and to design for the changing nature of work, service type, new facilities, etc.
- Clustering service and functional uses for example, combining fire, police, health, and administrative functions
- Fire stations should be located on or close to main arterials, but outside of areas that experience high volumes of traffic congestion, as well as disruption caused by train movements

Additionally, the spatial requirements within the meso scales which are related to the indicators such as accessibility, compatibility with adjacent land use and thresholds are given that;

- Fire stations should have direct and quick access to the major arterial with more than 22 m. width or sub arterial road to avoid any traffic congestion
- Not being located on a very busy arterial with travel speeds in excess of 40-45 mph (approximately 65-70 km per hour)

- Not being located near the roads or junctions of which levels of service defined by Highway Capacity Manual (HCM) will be between C and F within a planning term for not suffering from dramatic increase in response time caused by the lagging fire engines in traffic jam
- Locating a fire station near a controlled and signalised junction
- Entering the major street from the side street is facilitated by traffic signals controlled from the station, apparatus or dispatch centre
- Accessing with various modes of public travel to the fire station should be considered for public interaction.
- Being located away from the educational facility areas in order to avoid safety problems, interruptions on educational activities or undesired behaviours through interaction of students. Distance between the fire station and nearest educational area or land use should be determined ensuring the desired safety and comfort
- Not locating in the Special Uses Zone, including special public and private activities of an institutional or open character.
- Not locating in adjacent with preventive factors like gardens, agricultural lands, hills and so on, as it decreases the level of station response
- Co-locating fire and rescue facilities for maximum efficiency with other public facilities as well. (Consider including a training room for 50-100 persons in the design of new fire/rescue facilities unless there is a similar public facility available for the surrounding community.)
- Distance between stations should be decreased when there exists topographical thresholds, such as in the urban areas having high slope in the streets more than 10 per cent grade

- Leaving the station area and serving as many locations as possible following an earthquake led to a siting requirement that stations be located away from liquefaction wherever possible
- Accessing from the fire station site to the any portion of the response area could not be limited if a major earth event occurred
- Being best placed at central points in highly visible locations
- Providing focal elements (such as FS as a public service) of an urban structure that help to encourage a strong sense of community and identity
- Being required that the fire station appear to blend with other structures in the community

Finally, within the micro scales, the spatial requirements which are related to the indicators such as size, accessibility, future needs and extensions, compatibility with adjacent land use are presented that;

- Size of fire stations is defined according to variable issues such as population or population groups, settlement characteristics, types of fire stations, equipment, staff, and vehicles within the fire stations.
- The recommended plot size for permanent fire stations is between 3000 to 6000 square meters (1000-20000 square meters)
- Not locating in the corner or adjacent to the crossroads where there are traffic congestions
- Corner plot can be chosen, allowing easy entrance and exit with at least two alternative access points
- Entrances for apparatus bay and private car parking should be designed separately
- Not being located in one sided or parallel routes, as the lack of connectivity in local and one sided streets decreases the access of the stations

- Plot should also allow the station having direct access to maximum available directions
- Placing stations mid-block on side streets where entering the street is easiest
- Not locating a car parking on the street on which the entrance of the station also located
- Providing safe manoeuvrability on site and adjacent streets, to avoid vehicle structural stress, and for timely operation of apparatus and equipment should be required by relatively level location and enough area to manoeuvre.
- Accommodating reserve apparatus, emergency medical units and refund area for future growth
- Allocating specific plot of land for the rescue near the stations in the case of any incident and in usual time can be used as green space
- Facilities are required to shield neighbouring structures from headlights, sirens, truck noise, emergency lighting etc. and by use of shrubbery.

### 2.4. Legislation in Turkey

According to Balamir (1966, p.14), the subject of fire and fire fighting has been taken up as a legislative matter for more than a century. The current situation of the spatial aspects of fire services especially as a part of an urban area, still need to be improved and developed. Thus, the importance of improving legislation by defining spatial requirements of fire stations provides guidance and control through the implementation process.

The importance of thinking fire stations as an emergency response unit is not taken into consideration in the existing legislation in Turkey. Currently there are two main legislations present regarding the spatial aspects of fire services in Turkey. One of them is Development Law and the other one is Municipality Fire Department Regulation. They are briefly explained in the following sections.

### 2.4.1. Development Law 3194

In Turkey, Development Law 3194 with its Clause 44-I-b which is about the areas for the buildings of education, religious, health, sports, socio-cultural facilities and public institutions orients to the Legislation based on Urban Planning Principles (1985, revised in 1999).

The facility areas including educational, socio-cultural, health and urban administrative areas are elaborated within the scope of urban social and technical infrastructures in Development Law 3194. The details of urban administrative areas are not mentioned, therefore, the proposed calculation for prediction of total area according to population groups covers mixed functions. The most critical aspect of the clause is considering the emergency management services - fire stations, emergency medical services, police stations, rescue stations- as the same of the other urban administration areas such as governmental offices, court houses, prisons and other municipal facilities rather than emergency services.

The positive aspect of the clause when considering the criterion in foreign studies, “to meet the future needs”, is that the area has to be calculated according to the projected population.

**Table 2-7** Total Required Urban Administration Area per Population

| **Area per person** | **Population Group** |
|---|---|
| 3 m²/person | 0-15,000 people |
| 3,5 m²/person | 15,000-45,000 people |
| 4 m²/person | 45,000-100,000 people |
| 5 m²/person | 100,000+ people |

**Source:** Development Law 3194

In addition the calculation method to determine minimum area for the other facility which is stated by current Development Law as Emergency Aid and Rescue Stations within Health Services necessitates 130 m² per bed. However, the clause does not provide any details regarding size of fire stations.

According to BIMTAS (2003, p.170), when comparing to the international standards (as given in Table 2-8 below), in Turkey, the standard on urban administrative areas (3,00-5,00 m²/person) in Development Law 3194 propose a remarkable high value because the legislation was focused on Ankara where many of the public institutions exist.

**Table 2-8** Standards on Urban Administrative Areas

| **Countries and Researches** | **Urban Administrative Areas** |
|---|---|
| USA | 1,38 m²/person (proposal) |
| Germany | 0,80 m²/person (proposal) |
| France | 1,72 m²/person (proposal) |
| UK | 3,84 m²/person (proposal) |
| Italy | 0,30 m²/person (existing) |
| Canada | 1,00 m²/person (existing) |
| Portugal | 1,38 m²/person (existing) |
| Turkey | 3,00-5,00 m²/person (legislation) |
| Ankara Metropolitan Plan Office | 1,40 m²/person |
| Çetiner, 1972 | 0,50-1,00 m²/person |
| Günur, 1996 | 1,40 m²/person |
| METU, 1988 | 6,10-8,20 m²/person |
| Proposed Standard* | 1,40 m²/person |

* BIMTAS, 2003, Report of Proposals for Urban Public Services within the scope of the study by İstanbul Metropolitan Municipality, p.175

BIMTAS proposes a standard of 1,40m²/person urban administrative area (2003, p.175). It is also stated in the BIMTAS report (2003, p.171) that today, in developed countries, it can be said that the term "life quality" is used instead of "area per person". The quality of fire response is related not only to the population criterion, but also to the other criteria such as geological structure and the number of fire station areas. Additionally, location of the fire stations, which is not mentioned in the current development law, is also another important stage of the planning of fire services in Turkey.

### 2.4.2. Municipality Fire Department Regulation (2006)

Generally, the purpose of the regulation to provide minimizing probable fires which are break out at the stages of design, build, management, maintenance and use of all structures, buildings and facilities, and also to determine the principles of prevention, organisation, training and control in order to provide minimizing life and property losses by fire suppression.

The main parts of the regulation include only the issues such as function and risk class of building, fire safety in buildings and the details within the scope of architectural context such as accessible means of egress, divisions of buildings, electric wiring, smoke management system, fire suppression systems, storage and use of hazardous material. In addition to the architectural clauses, other clauses about crew, education, control, cooperation and budget are explained.

The clauses which give us only clues in spatial requirements within the scope of urban level are presented below;

> Part 2 - Institute, Mission and Working Arrangement
> i) To determine the location of explosive and flammable material storage according to the site plan
> Part 4 - Mission of Fire Station Chief
> a) To provide the service being managed effectively and efficiently by planning, conducting, coordinating and controlling the fire services and the support services as a whole, according to the fire fighting strategies.
> e) To make general plan on transportation in order to reach water sources and access to fire area then show this plan/schema on the city map in 1/25.000 scale.
> Part 11- Vehicle, Equipment and Materials
> Clause 42 – (1) The minimum number of fire station vehicles is determined based on the following criteria in accordance with the related TSE (Institute of Turkish Standards) and EN standards.

It is stated in Municipality Fire Station Legislation that the types and the minimum number of vehicles distributed considering the population groups.

**Table 2-9** Types & Minimum Number of Vehicles according to Population Groups

| **TYPES & MINIMUM NUMBER OF VEHICLES** | **POPULATION (people)** |
|---|---|
| 1 fire extinguishing vehicle | less than 10.000 |
| 2 fire extinguishing vehicles, 1 vehicle with ladder and 1 emergent rescue vehicle | 10.000-25.000 |
| 3 fire extinguishing vehicles, 1 vehicle with ladder, 1 double-cabin pickup, 1 service vehicle and 1 emergent rescue vehicle | 25.000-50.000 |
| 4 fire extinguishing vehicles, 1 vehicle with ladder, 1 double-cabin pickup, 1 service vehicle, 1 ambulance and 1 emergent rescue vehicle | 50.000-100.000 |
| 6 fire extinguishing vehicles, 2 vehicles with ladder, 2 double-cabin pickups, 1 service vehicle, 1 ambulance, 1 multi-functional rescue vehicle and 1 emergent rescue vehicle | 100.000-200.000 |
| 8 fire extinguishing vehicles, 2 vehicles with ladder, 3 double-cabin pickups, 1 service vehicle, 2 ambulances, 1 multi-functional rescue vehicle and 1 emergent rescue vehicle | 200.000-300.000 |
| 10 fire extinguishing vehicles, 3 vehicles with ladder, 3 double-cabin pickups, 2 service vehicles, 2 ambulances, 2 multi-functional rescue vehicles and 1 emergent rescue vehicle | 300.000-400.000 |
| 14 fire extinguishing vehicles, 4 vehicles with ladder, 4 double-cabin pickups, 2 service vehicles, 3 ambulances, 2 multi-functional rescue vehicles and 2 emergent rescue vehicles | 400.000-600.000 |
| 14 fire extinguishing vehicles, 4 vehicles with ladder, 4 double-cabin pickups, 2 service vehicles, 3 ambulances, 2 multi-functional rescue vehicles and 2 emergent rescue vehicles<br>In addition 1 fire extinguishing vehicle*<br>1 vehicle with ladder, 1 ambulance and 1 multi-functional rescue vehicle**<br>1 emergent rescue vehicle, 1 double-cabin pickup and 1 service vehicle*** | more than 600.000 and<br><br>In addition<br>for each 150.000 people*<br>for each 400.000 people**<br>for each 500.000 people*** |

Adapted from Municipality Fire Department Regulation (2006)

# CHAPTER 3

# CASE STUDY OF ANKARA

In this section, site selection and design process of fire stations in Ankara are analysed. Accordingly, the interview with the authorities of Ankara Fire Department, observations and the information regarding fire services of Ankara are presented. Also, site selection and design criteria of fire stations which are compiled with the help of reviewed literature are examined in the case study of Ankara. Advantageous and disadvantageous aspects of several fire stations are evaluated regarding spatial requirements. Finally, some criteria specific to Ankara are clarified in macro, meso, micro scales according to the available information that could be collected in this study.

## 3.1. The reasons of choosing Ankara for the case study

There exist several reasons to choose Ankara for the case study as presented below;

- being strategically important as the capital and administrative focus of Turkey,
- necessity of pioneering on role of planning systematically, as defined in the purposes of being chosen as the capital city,
- many landuse having high risk in fires such as shopping malls, hospitals, interchanges, underground metro,
- urban sprawl with high rise buildings and high density population around urban periphery,
- increase in the total number of fires annually and high response time value.

Quantitative data retrieved from the Fire Department of Ankara Metropolitan Municipality, regarding the total number of fire incidents between the year of 1997 and 2006 is given in Figure 3-1. In addition, number of fires increases to 7062 during the year 2009. Increase of fire incidents necessitates the fire services to be improved in Ankara.

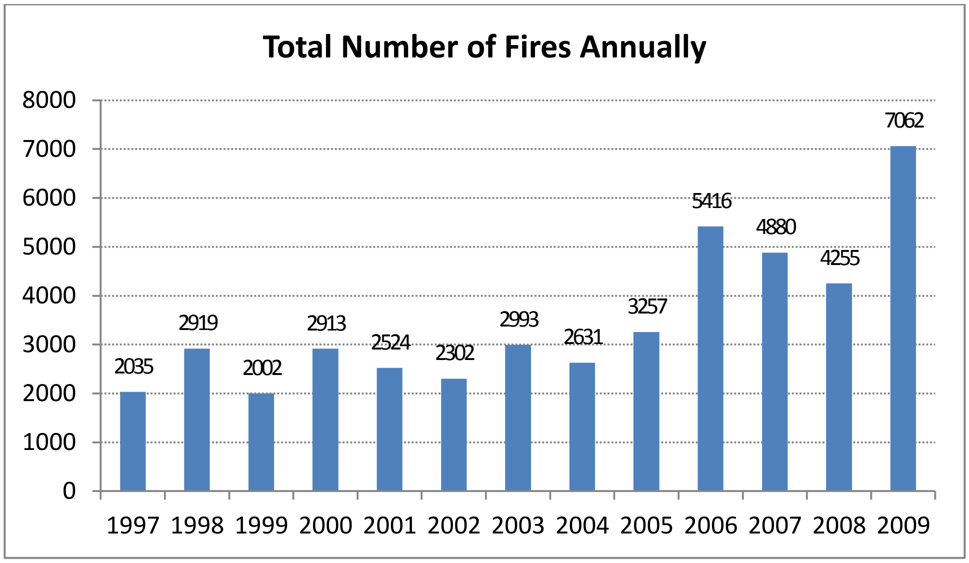


**Figure 3-1** Number of Fires between 1997 and 2009

[Adapted from http://www.ankara.bel.tr/AbbSayfalari/hizmet_birimleri/Itfaiye/1997_2006_yangin_sayisi.aspx, 02.11.2010]

Several statistical data (Table 3-1) related to the fire response services are evaluated in order to provide general perspective on the issue. When the response time values in 2008 and 2009 are compared, it is observed that generally, response time decreases from 2008 to 2009. In addition, response time values of Ankara and Istanbul are higher than the other two examples of London and New York City.

According to Alkış (2009), from Akdeniz University, Vocational School of Technical Sciences, Fire Fighting and Fire Safety Program, the number of fires cannot be determined accurately due to insufficient statistics of fires in Turkey as seen in Appendix-XV. However, it is predicted that approximately a hundred thousand fires break out annually (Alkış, 2009). As in the example of New York City, fire statistics are kept in detail, classifying fire types such as structural and non-structural.

**Table 3-1** Examples of Statistical Data related to Response Times (2008-2009)

| | **Response Time (min:sec.)** | |
|---|---|---|
| **Fire Departments** | **2008** | **2009** |
| **New York City (NYC)*** | 4:22 (S); 4:47 (Ns) | 4:05 (S); 4:29 (Ns) |
| **London (LFB)** | 5:32 | - |
| **Istanbul** | 6:37 | 6:26 |
| **Ankara** | - | 5-12** |
| * The data, number of fires, is given in two categories which are Structural fires (S) and Non-structural fires (Ns)<br>According to NFPA Glossary of Terms (2004), Structural fires are seen in buildings, enclosed structures, aircraft interiors, vehicles, vessels, aircraft, etc. and the non-structural fires are the other fires such as wildland fires, forest fires, etc. | | |
| ** The response time in Ankara, indicated by Kurutuz (the manager of Ankara Fire Department) within the interview hold on 08.03.2010, is between 5-12 minutes and their goal on response time is between 5-8 minutes (seconds are not indicated). | | |

**Sources:**
City of New York Fire Department, Annual Report, 2008-2009,
[http://www.nyc.gov/fdny, retrieved on 02.11.2009]
London Fire Brigade, Our Performance 2008/09
[http://www.london-fire.gov.uk/Documents/Our_Performance0809.pdf, retrieved on 28.05.2010]
Istanbul Metropolitan Municipality Fire Department, Statistics 2009,
[http://www.ibb.gov.tr/sites/itfaiye/istatistikler/Documents/2009/2009_kurum_disi.pdf, retrieved on 09.04.2010]
Ankara Metropolitan Municipality Fire Department, Statistics 2009,
[http://ankara-bld.gov.tr/AbbSayfalari/hizmet_birimleri/Itfaiye/faaliyetler/aralik_2009/2009_tum_ilceler_yangin.pdf, retrieved on 04.01.2010]

Additionally, response time increases towards urban periphery especially due to the urban sprawl within the responsibility of Ankara Metropolitan Municipality. Increase in response time causes inadequate coverage of fire stations in the responsibility zone.

### 3.2. Fire Department of Ankara Metropolitan Municipality

Fire fighters called “tulumbacilar” was firstly located in Hergele (Hergelen) Square in Ankara around the beginning of the year 1922. Later, name of Hergele Square is changed to Iftaiye (Fire Station) Square due to the location of the central Fire Station of Ankara in that area (Esmer, 1985, p.417). The importance of fire station is its location between the old city centre-Ulus and new city-Yenisehir, and its coverage of functions such as several commercial areas, public spaces, governmental buildings, and industry.

Following urban development of Ankara, number of fire stations increase to 14 in 2003 (Ertugay, 2003, p.63). After the Metropolitan Municipality Law numbered 5216 in 2004, radius of the responsibility zone of Metropolitan Municipality is extended to approximately 50 km. Today, there are 26 fire stations present in Ankara under the coverage of metropolitan municipality. Spatial distribution of fire stations in Ankara Metropolitan Municipality boundary can be considered in three types of groups such as Urban Core, Urban Periphery, and Outer Districts. Fire stations of Ankara are shown on the satellite map given in Figure 3-2.

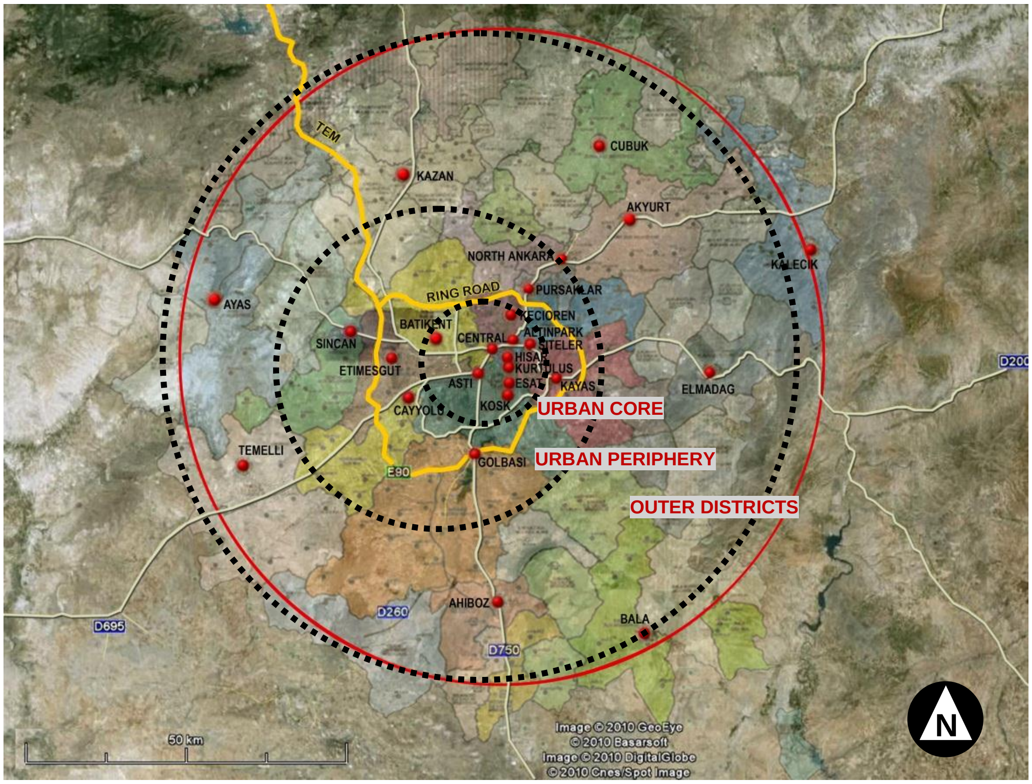


**Figure 3-2** Satellite view of Ankara and Fire Stations according to their location in Urban Core, Urban Periphery and Outer Districts

Satellite map of fire stations which are located in the urban core and the urban periphery are shown in Figure 3-3.


**Figure 3-3** Satellite View of Fire Stations Located in Urban Core and Urban Periphery of Ankara

List of stations according to that classification is presented in Table 3-2.

**Table 3-2** Fire Stations within the responsibility of Ankara Metropolitan Municipality

| Urban Core | Urban Periphery | Outer Districts |
|---|---|---|
| Central Fire Station (Headquarters) | Sincan | Kalecik |
| Hisar (Kale) | Etimesgut | Elmadag |
| Kosk | Batikent | Bala |
| Kurtulus | Cayyolu | Ahiboz |
| ASTI | Golbasi | Temelli |
| Esat | North Ankara | Ayas |
| Altinpark | Pursaklar | Kazan |
| Kecioren | Siteler | Cubuk |
| | Kayas | Akyurt |

[Adapted from http://www.ankara-bel.gov.tr/AbbSayfalari/hizmet_birimleri/Itfaiye /gruplarimiz.aspx, on 19.09.2010]

Current locations of fire stations given in Appendix-XIV in details are classified below, regarding their cooperation with other emergency services, compatibility with adjacent landuse, coverage area character.

- Cayyolu and Akyurt Fire Stations are located near the police station or gendarmerie which allow cooperation between the services

- In Ankara, 12 of fire stations are located in municipal property, 10 of fire stations are allocated valid for service, and 4 fire stations are located on rented property. For instance, Temelli, Bala, Pursaklar, Ayas, Kazan, Kalecik fire stations are located inside the area of municipal units especially garage.

Locating fire stations on a municipal property is a very cost effective solution as well as having the benefit from cooperation between other municipal facilities. However, site selection of fire stations should be primarily based on ensuring response time targets. Therefore at the early planning stages, public properties should be identified for emergency services.

- Hisar (Kale), Kosk and ASTI are special departments and only responsible from their specific zones which are historical Kale (The Castle) region, Presidential Palace (Kosk) and Ankara Intercity Bus Terminal (ASTI). The other fire stations are responsible from the fires that take place in their fire responsibility zones (Ertugay, 2003, p.63).

- Siteler, Sincan, Temelli and Batikent located near the industrial zones and providing service to their residential areas.

## 3.3. Implication of criteria according to urban scales

In this section, site selection and design criteria of fire stations which are classified according to urban scales, and evaluated considering the fire stations of Ankara.

### 3.3.1. Macro

Several criteria indicators such as coverage area, urban characteristic regarding fire risk, location of fire services in urban macroform, distance between fire stations, future needs and possible expansions of fire services are explained in this section, including several examples of implications in Ankara.

Population criteria are not the only indicators of fire station location. Character of coverage area and its fire risk is one of the factors, influencing the location of fire stations. When the major fire incidents happened between 1929 and 1974 in Ankara are reviewed, it is seen that almost 50 per cent of them occurred in the industrial areas (Esmer and Baran, 1983, p.417). However, according to the fire statistics, number of fires happened in industrial zones is around 1 per cent of the total fire incidents occurred in Ankara during the year 2009.

Considering the fire statistics, change in the urbanisation character also effects the main reason and type of the majority of the fires. Today, fires are mostly being suppressed before turning into disasters when compared to fires in the past, however, high density residential developments, underground metro, interchanges/tunnels, shopping malls, hospitals and such urban landuses still have a high risk of disaster like fires.

According to the data which is provided by Fire Department of Ankara Metropolitan Municipality (2010), including reports of 27 fires breaking out between January-July, 2009 in Ankara Altındağ District, it is observed that the average response time is 7,96 minutes and the maximum response time is 13,0 minutes in the fire reports of 27 incidents.

Considering the historical centre settled within the district, the response times are quite high. Response time should be decreased to a value lower than 5 minutes in urban areas. The area is a fire risk zone because of both being a historical settlement which has an organic pattern and contains timber material buildings and also being comprised in squatters, commerce and small scale industry, depots. Especially for historical centre, Hisar Fire Station cannot provide fire response under the targeted response time. Distance between Hisar and near fire stations can be decreased, considering accessibility and thresholds, to a value lower than the average distance, which is 2,4 km, as given in Table 3-3.

**Table 3-3** Distances and average distance between Hisar Fire Station and nearest stations

| | Distance to near stations (km) |
|---|---|
| Hisar - Kurtulus | 1,42 |
| Hisar - Headquarters | 2,79 |
| Hisar - Altinpark | 2,88 |
| ***Average distance between stations:*** | ***2,40*** |

Distance between the neighbouring fire stations, classified according to location, are measured from satellite maps and presented in Appendix XIII. Minimum and maximum values of measured distances between fire stations taking place at the urban core, urban periphery and outer districts of Ankara varies between 1,42 km for Kurtulus to Hisar and 5,02 km for Asti to Esat; between 4,93 km for Kecioren to Pursaklar and 13,49 km for Cayyolu to Golbasi; and between 12,09 km for North Ankara to Akyurt and 27,68 km for Cayyolu to Temelli respectively, as given in Table 3-4.

**Table 3-4** Maximum and minimum distances between nearest fire stations located in urban core, urban periphery and other districts

| **Location** | **Fire Stations** | **Distance to near stations (km)** |
|---|---|---|
| Urban Core | Kurtuluş - Hisar | 1,42 (min.) |
| | Asti - Esat | 5,02 (max.) |
| Urban Periphery | Kecioren - Pursaklar | 4,93 (min.) |
| | Cayyolu - Golbasi | 13,49 (max.) |
| Outer Districts | Kuzey Ankara - Akyurt | 12,09 (min.) |
| | Temelli - Cayyolu | 27,68 (max.) |

Average distances among Ankara fire stations are calculated as 3,4 km in the urban core; 8,1 km in the urban periphery and 22 km in the outer district. According to Liu et al. (2006, p.363), it is suggested for fire stations to be located between 1 km to 9km far from another fire station, ensuring the targeted response time to be met. It can be evaluated that, distance between nearest fire stations increases from urban core to outer districts.

Processes of site selection for new fire stations mostly start with the official application of the fire department to the responsible municipality in order to improve the fire services in an urban area having unacceptable fire risk. Then, municipality makes necessary revision in the plan and suggests a plot for the proposed fire station. Afterwards, fire department decides whether the plot is suitable for the proposed fire station or not. If the plot is not suitable, then another revision of the plan is requested from the municipality.

As an example of site selection processes for a new fire station in Dikmen, Fire Department requests a suitable area to be allocated in the plans of Dikmen in 2003, reporting deficiencies on fire services due to increase of traffic congestion and population build up in the area. Following the request of Fire Department, Ankara Metropolitan Municipality makes revisions on the zoning plan and allocates a specific plot for a fire station in that area.

Another example of macro scale criteria can be reviewed in Cayyolu Fire Station regarding the coverage area where the station should respond. Satellite view of Cayyolu Fire Station and its coverage are given in Figure 3-4.

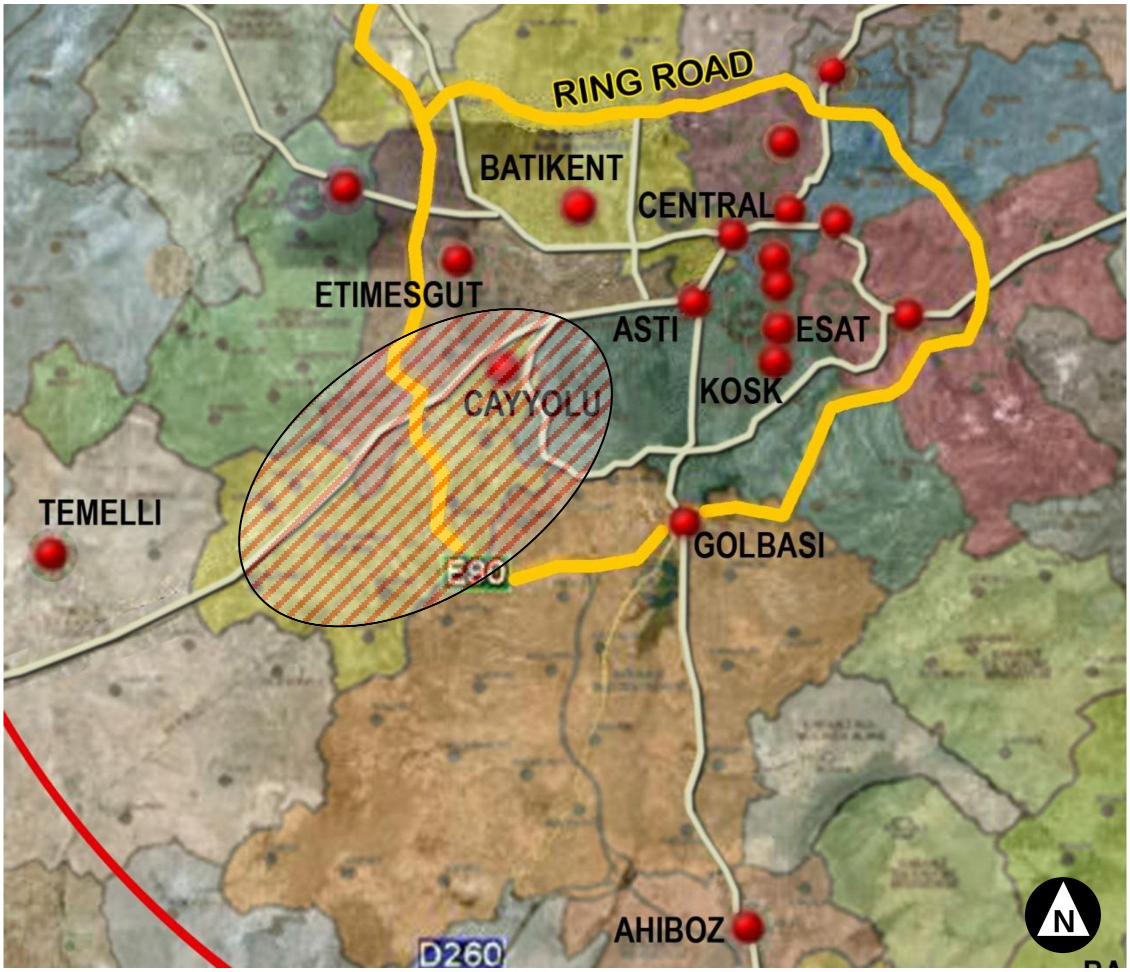


**Figure 3-4** Satellite view, showing the general coverage area of Cayyolu Fire Station and neighbouring stations located in urban periphery of Ankara

It is seen in Figure 3-4 that, nearest fire station to Cayyolu Fire Station is Etimesgut Fire Station which is 6,63 km far from Cayyolu in the Northern side. Cayyolu Fire Station is providing fire response to a relatively large coverage area in Yenimahalle and Cankaya districts. Its coverage are includes both two sides of Ankara-Eskisehir Highway approximately from Asti to Temelli as shown in the shaded area in Figure 3-4. Additionally, Southern part of the Ring Road towards Golbasi is under the responsibility of Cayyolu Fire Station.

Cayyolu Fire Station reports several inadequacies on the fire services due to their responsibility area and requests extension from the Metropolitan Municipality. Afterwards the plans are revised and plot size is enlarged in order to accommodate future requirements of the station. The station is enlarged, however, due to the urban sprawl and development of urban area towards the outer side of the Ring Road, new fire stations should be located in order to provide satisfactory fire services in the future. Urban development through Turkkonut, Alacaatli, Yasamkent, Baglica and Beysukent, especially with high rise buildings and character of high density population significantly necessitates improvement of fire services in that area.

### 3.3.2. Meso

Indicators of site selection and design criteria of fire stations; such as accessibility, compatibility with adjacent landuse and urban thresholds, which can be classified under meso scale, are reviewed on several examples of implications in Ankara.

In terms of accessibility, fire stations should be located allowing direct and quick access to major arterials without traffic congestion and including alternative exit routes, preferably near a signalised junction which can also be controlled by the fire station. Additionally, fire station should not be located on a major arterial having high travel speeds such as more than 65 km per hour (EnviroIssues et al., 2008, p.3).

For instance, one of the advantages of Cayyolu Fire Station location is providing satisfactory accessibility to major arterials through wide roads having average travel speed lower than 65 to 70 km per hour is another advantage. In addition, there are also signalised junctions where the roads coming through the station is connected to main arterials as shown in Figure 3-5. The area surrounding the fire station is accessible with various modes of public transport -including underground metro which is under construction- in order to provide public interaction such as fire safety educations or workshops.

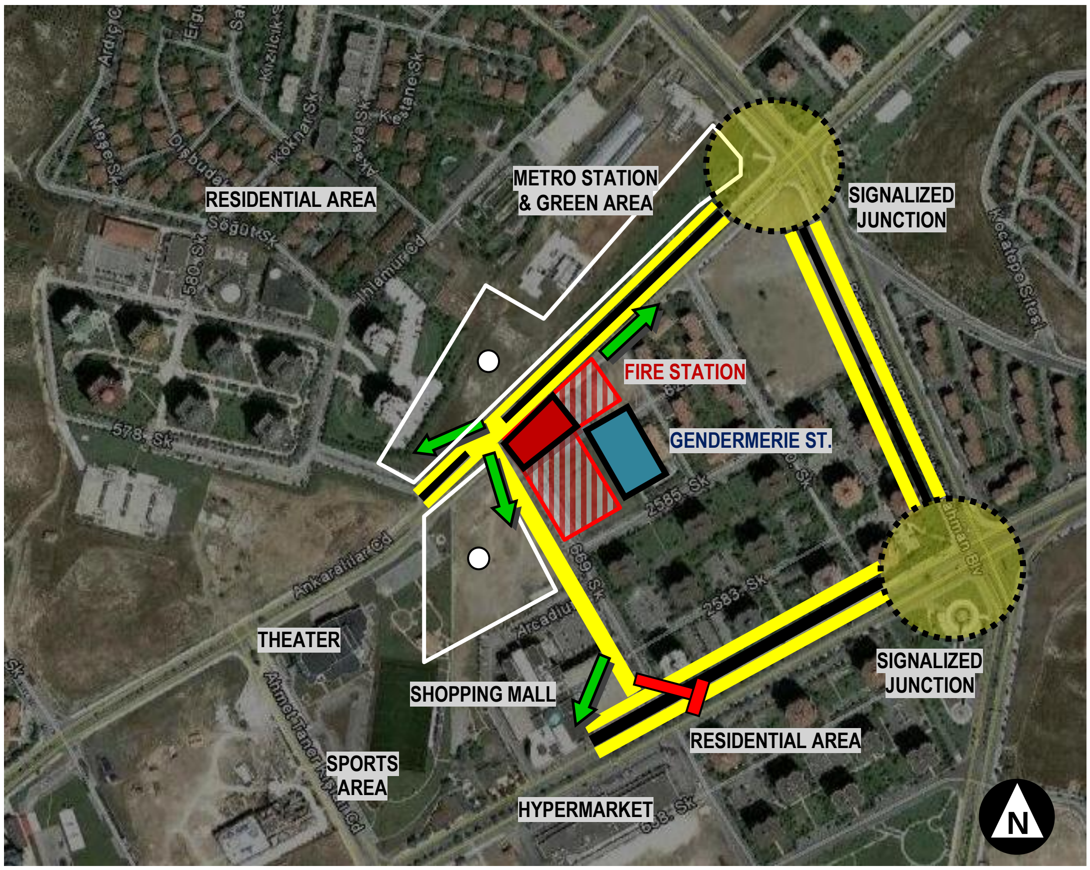


**Figure 3-5** Cayyolu Fire Station and its surroundings

Gendarmerie is located next to the fire station which is advantageous for the cooperation between these facilities. There are other advantages when considering the compatibility with adjacent land use. For example, sports area can be used by fire station personnel in order to provide training on a shared basis.

On the contrary, the disadvantage of Cayyolu Fire Station is being located near the central area where there is a theatre, a shopping mall and a hypermarket. Therefore, it is necessary to consider the negative effects of rush hours and to provide safety for both pedestrian and vehicles.

Another example of inadequate siting of fire station is seen in the zoning plan suggested by the Metropolitan Municipality regarding the proposed Dikmen Fire Station, which is located in an area next to three educational facilities. Following that revision, Fire Department suggests another revision for enlarging its plot area by merging the neighbour plot which was planned as a primary school area. As it is seen in the plan drawing, suggestion of Fire Department is advantageous considering possible future extension of the station; however there still exist problems due to the location of educational facilities which are taking place next to the station.

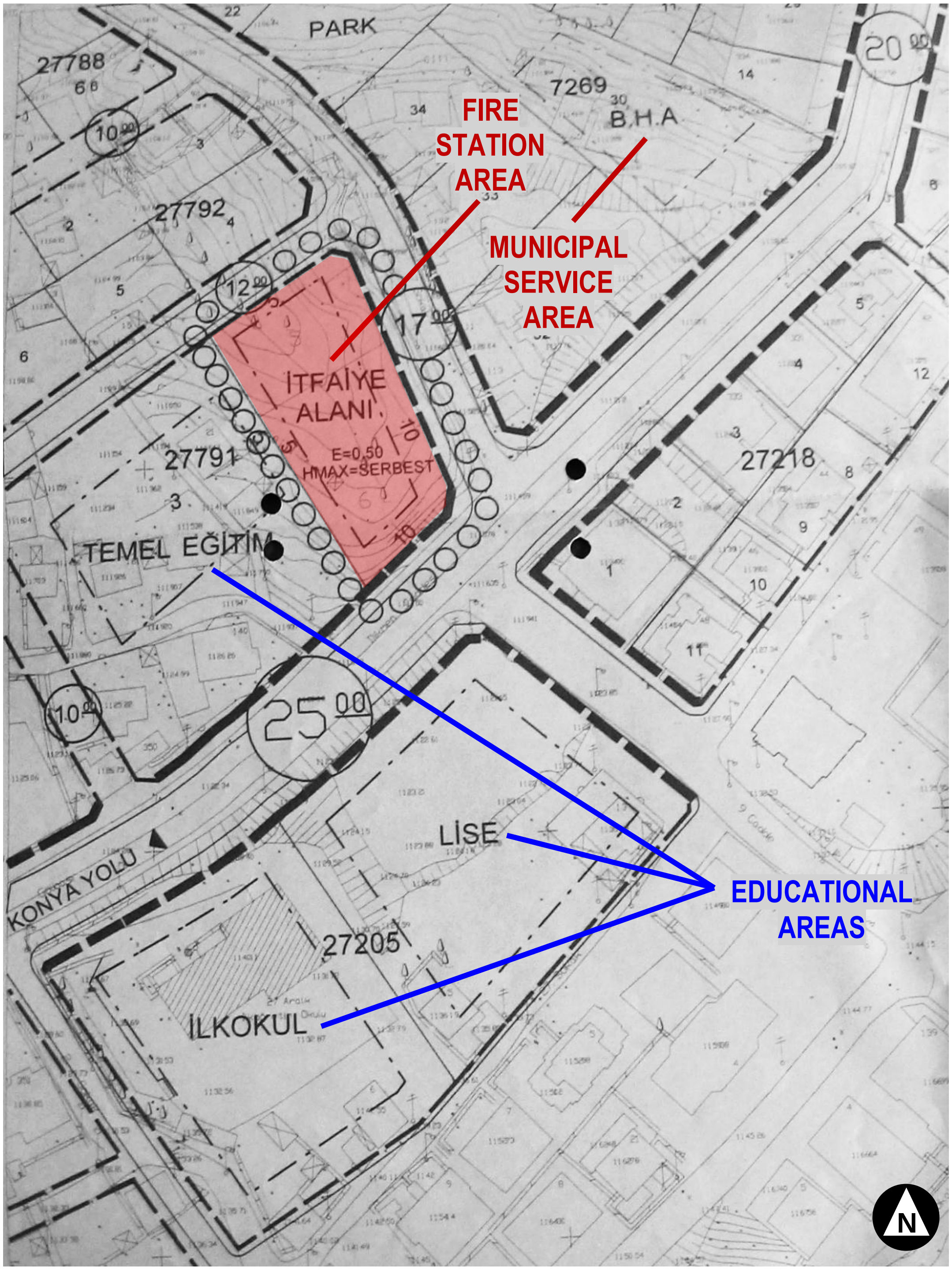


Figure 3-6 Zoning Plan of Proposed Fire Station in Dikmen

### 3.3.3. Micro

Indicators of site selection and design criteria of fire stations; such as size, accessibility, future needs and extension, compatibility with adjacent landuse which can be classified under micro scale are reviewed on several examples of implications in Ankara.

One of the advantages of Cayyolu Fire Station regarding the indicators in micro scale is that Cayyolu Fire Station not being located next to the residential area directly, which is not desired considering disturbance to residents. There are also empty plots can be used as a buffer between the fire station and the residential areas. Additionally, Cayyolu Fire Station is located on a flat area, without possible topographical thresholds to cause accessibility, manoeuvrability or siting problems.

The other advantageous aspect of Cayyolu Fire Station location is providing access to available alternative routes to neighbourhoods such as Koru, Konut1-2 and Umitkoy. In front of the fire station, there is a break present on the secondary road allowing access to both two directions. However, the main road in the south-east of the station is a divided road which is undesirable because of limiting left-turns to the signalized junction.

Other examples regarding the implications of site selection and design criteria in micro scale are reviewed on a proposed fire station in Dikmen. The proposed station is an example of an end-block location. Although this location and plot form having three facades to the roads provides alternative access, for this site, it cannot be an advantage because of high slope as seen on the project of fire station presented in Figure 3-7. This also causes time loss and manoeuvrability problems.

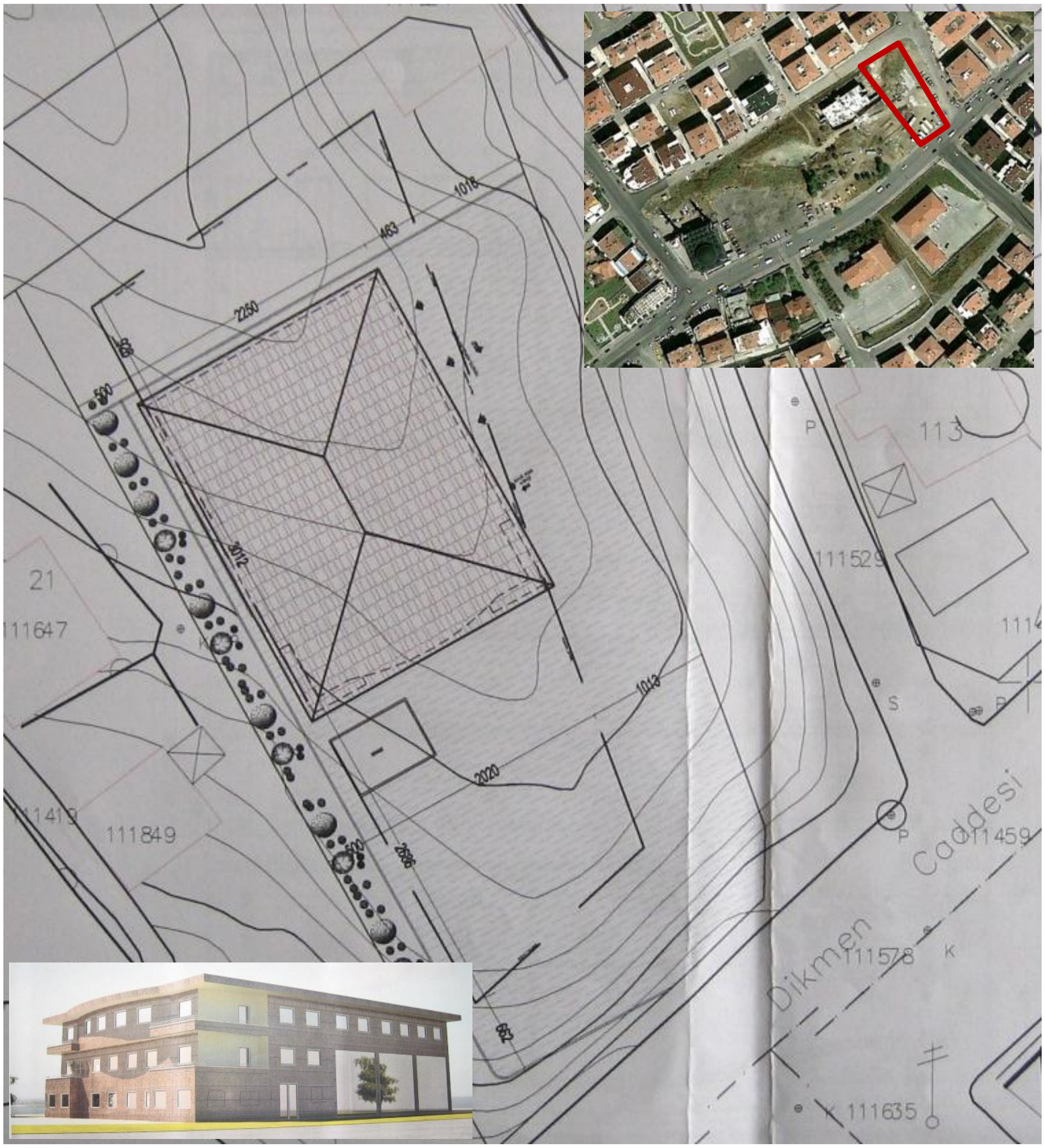


**Figure 3-7** Project of Fire Station Proposed in Dikmen

### 3.4. Evaluation of Fire Services in Ankara according to Legislation

In this section, legislation regarding fire services, which are Development Law 3194 and Municipality Fire Department Regulation, evaluated for the case study of Ankara.

#### 3.4.1. Evaluation of Fire Services in Ankara according to Development Law 3194

The only criteria exists within the scope of Development Law 3194 is the size of area per person for all types of Urban Administrative Areas according to the population. It is mentioned in the law that Urban Administrative Area should be 5 square meters per person for populations more than 100.000 people. Considering the approximated population of Ankara Metropolitan Area with 4.000.000 people, there should be 20.000.000 square meters of Urban Administrative Area. According to Brandt, minimum of total Fire Station Area is suggested to be at least 0,03 square meter per person in metropolis, resulting 120.000 square meters of Fire Station Area for Ankara. The ratio of Minimum Total Fire Station Area in Urban Administration Area is calculated as 6‰. Accordingly, required minimum total fire station area is calculated in Table 3-5.

**Table 3-5** Required Minimum Total Fire Station Area in Ankara

| | Population | Reference | Administrative area per population ($m^2$/person) | Administrative area ($m^2$) | Fire station area (5) [min 6‰ of admin. area] ($m^2$) |
|---|---|---|---|---|---|
| (1) | 7.440.802 | Legislation (3) | 5 | 37.204.010 | 223.224 |
| | | BIMTAS proposal (4) | 1,4 | 10.417.123 | 62.503 |
| (2) | 4.339.941 | Legislation (3) | 5 | 21.699.705 | 130.198 |
| | | BIMTAS proposal (4) | 1,4 | 6.075.917 | 36.456 |

(1) Projected Population for Trend Development of Ankara in 2023 according to Ankara Metropolitan Municipality
(2) Population of Ankara Metropolitan Area in 2009 according to TUIK (UAVT)
(3) Development Law 3194
(4) Administrative area proposed by BIMTAS
(5) Minimum Fire Station Area, suggested as 6‰ of Urban Administrative Area

### 3.4.2. Evaluation of Fire Services in Ankara according to Municipality Fire Department Regulation (2006)

Municipality Fire Department Regulation includes a criterion to determine the required number of personnel and vehicles according to the population of a coverage area. The number of personnel and vehicles can be used to determine required plot size of a fire station area based on an architectural induction.

The number of total personnel in Ankara Fire Service is 916 in October, 2010 according to information collected from the web site of Ankara Metropolitan Municipality Fire Department. As explained in the literature review, according to Municipality Fire Department Regulation which recommends minimum 18 personnel for 60.000 people, for the population approximately 4.000.000 people, approximately 1.200 personnel is required in total.

Additionally the number of current fire vehicles used in Ankara and required vehicles according to the population-based regulation are compared. The current vehicles are varied in types allowing several functions such as fire extinguishing vehicles for narrow roads and foam towers; however, number of some vehicle types is less than the required amount, such as ambulances, rescue vehicles and vehicles with ladders as presented in Appendix-XVI.

### 3.5. The Interview

In order to obtain more information about the existing process, technical and statistical data related to the fire response service in Turkey, an interview with the administrators of Ankara Fire Department is hold in 2010. The clues are searched about site selection and design of fire station within the scope of interview. Accordingly, the examples of fire reports, correspondence by institution and experience mentioned by administrators are evaluated.

A face to face-unstructured interview is preferred in order to provide flexibility through the interview and also to reach all of the situations and opinions related spatial dimensions of fire stations and the pre-implementation process in a wide perspective. The declarations of the interviewees presented in Appendix-IX which are reviewed prior to interview. Additionally, key words on main issues guiding the interview and list of demanded site specific data, information and opinions are arranged for using during the interview as seen in Appendix-X.

- Interviewee-1:

Director of the Fire Department in Metropolitan Municipality of Ankara, Faruk Kurutuz states that there is lack of legal regulations about where a fire station should be located and how it should be designed. He says that it proceeds in a manner of such a mentor system and subjective decisions depending mostly on experiences rather than an official guideline.

He explains that the size and type of fire stations in new developing areas are determined by population, fire risk and density of traffic in these regions. According to Kurutuz, the most essential point about location and design of fire stations is that a station should have alternative entry-exit points to provide direct access to all of the directions easily. Fire stations should be located to the most suitable place in terms of traffic flow which ensures to reach the incident quickly.

According to Kurutuz (2010), generally at the early stage of the urban planning, site selection and design of a proposed fire station is not considered by municipality. He adds that, when there appears a need of improving fire service by extending the area of an existing station or proposing a new fire station, fire department authorities apply to municipality for plan revision. Kurutuz also states that, following the plan revision, proposed fire station area is specified with the specific legend title named “fire station area”. He criticizes that the site selection and design decisions taken by municipality are more important.

He states that surely, new fire stations will be determined in the region where it is needed, by the municipality with the approval of mayor. Additionally, he states that, there is neither a regulation, nor a guideline assisting the process of site selection and size of new additional fire stations rather than experiences of the administrators of local fire departments.

He also talks about excessive amount of water carried by fire truck in Turkey. He states that fire trucks in developed countries carry no more than 2 tons of water whereas the fire trucks in Turkey carry 5 to 10 tons of water. He mentions that there are fire hydrants in every street and avenue, approximately in every 200 meter, in developed countries. As a result of this, they don’t need a lot of trucks or external supply of water.

Using light weight fire extinguishing vehicles by the help of less water loads can be evaluated as the response time will decrease if the infrastructure of the urban area is efficient, such as including fire hydrants. Also, the responsibility zone can be enlarged if the response time is shorter than the targeted period; therefore, the distance between the stations can be increased.

He thinks that sometimes Conservation Site Law in Turkey can cause difficulties in terms of fire response within the conservation areas such as historical city centres. A lot of cities in Turkey have difficulties because of this law. He claims that many districts having old structuring turned into hovel due to this law. However, as all of these areas are conserved as a historical site, nobody intervenes these areas. In case of fire incidents in these areas, sometimes it is impossible to reach the fire scene by the fire engines due to the narrow streets or limited access. As a result, some historical artifacts which really need to be protected are damaged and disappear. Therefore, he suggests that Protected Area Law should be revised according to the current condition, hovels should be eliminated and historical artifacts in these areas should be preserved.

He claims that Kale Historical Region, their small unit in Hisar, cannot provide satisfactory fire service. On the other hand, it is impossible to use a large fire engine in there because there is no entrance for such a vehicle. Therefore, he states that there are only a few small vehicles staying in Hisar, which can make first response.

- Interviewee-2:

Yakup Sarı, who is the Deputy Director of Fire Department in Metropolitan Municipality of Ankara, thinks that some of the new fire stations have problems in terms of access to the building which are not convenient in terms of garage entrance. Moreover, he adds that, manoeuvrability of the large fire engines is sometimes an issue for the buildings of some fire stations. He says that, when it is asked that why it is like that, it was said that this plan was approved by the municipality. Namely, he addresses that when the criteria for the fire service are not declared correctly and clearly, a garage can be built but cannot be used.

When he is asked about the sports and exercise facilities of the fire department, he mentions that there was a playfield for firemen in the past. However, he says that nobody can predict when a fire is alarmed. In other words, they didn't have enough time to complete an activity because whenever they began to exercise, there was a fire which occur somewhere in the region. Therefore, firemen had to leave the activity and they hadn't have time for change their clothes. He states that if they are sent to the fire scene with their sportswear, it may damage the department's reputation. Therefore, he states that they couldn't manage it. This is another situation showing that the current fire response services are running within the control of subjective decisions and experiences of the local administrators in Turkey.

Additionally, he talks about their hydrants. He states that these hydrants' place is determined by Ankara Water and Sewerage Administration-ASKI. He also says that some of their hydrants are closed during the road works and fire crews occasionally check the hydrants in order to determine whether the hydrants are active or not. He states that their 26 stations have assigned positions but if they try to put a sign into the 1/25000 scaled map for their stations, people may have difficulty to read the street names.

When he is asked about how they obtain landuse for new fire stations of expansion of existing stations, he implies that, decision of expropriation may be given but it is preferred that foundation should be established by itself in order to diminish the cost.

He says that there isn't any plan about which crew will go for in certain time periods according to density of traffic. He explains that employee in the central office of emergency fire response call centre orientates the firemen. Central officer informs the police through calling 155 and says that the traffic flow is slow. He mentions that when there is a traffic police, road may be discharged in advance for access of fire vehicles. Both the cooperation between emergency services and the coordination between the units within the fire services operate depending on subjective decisions.

# CHAPTER 4

# RESULTS & DISCUSSIONS

According to the literature review, opinions of the experts, case study of Ankara, qualitative and quantitative data; fire stations have spatial deficiencies in urban scale in Turkey. Legal instruments concerning the site selection and size of fire stations are clearly superficial and insufficient, causing subjective implementations to take place depending on the individual experiences of the local authorities when making decisions on setting up or improvement of the current fire service. Information presented in the previous sections are evaluated and combined in this section in order to present a set of guidelines and recommendations mentoring the site selection and spatial implementation of the fire stations in Turkey.

Primarily, Fire Stations should be considered as an Emergency Service in the official plans rather than Urban Administrative Area or Municipal Service Area. According to the current legislations, fire stations are considered as any of Administrative units by means of area, which can be available for governmental offices, court houses, prisons and other municipal facilities rather than emergency services as well. Legal setting of land allocation for fire stations should be upgraded in detail, considering fire stations as an emergency service in the official plans instead of Administrative Area or Municipal Service Area. Detailed legislation needed for site selection and design of fire stations.

Total size of required administrative area is defined as a value between 3,00 to 5,00 square meters per person in the current development law in Turkey, which is valid for allocation of all administrative areas, but not specific to fire station areas. Required total area size of the fire stations should be considered in particular to the fire stations, which should be between 0,01 square meters to 0,10 square meters per person, with a suggested minimum value of 0,03 square meters for metropolis.

Additionally, the recommended plot size for a permanent fire station is between 3000 to 6000 square meters. Optimum plot size of fire stations are defined according to the practices reviewed in the literature survey. The minimum plot size of a fire station should be at least 1000 square meters.  Moreover, maximum plot size can rise up to 20000 square meters which is according to the additional desired services for the station such as communication centre, exercise yard, workshop. Plot size of fire stations also varies with the needs of covered population in order to ensure providing service to multiple fire incidents synchronously.

An important stage of the planning of fire services is site selection, which is neither mentioned in the current development law nor in any related regulation in Turkey.

The most important factor influencing the site selection of fire stations is the relation between response time and coverage area. Additionally, settlement character in the responsibility zone of a fire station influences the targeted response time. Even though response time target changes depending on character of coverage area, targeted response time in high risk category areas is suggested to be lower than 5 minutes. Aiming to decrease the response time, distance between fire stations can be decreased spatially.

According to the examples of site selection process of new fire stations in Ankara, firstly the fire department applies to the metropolitan municipality in order to improve the fire services in an urban area suffering from fire risk. Afterwards, municipality revises the plan and suggests a plot for the proposed fire station. Then, fire department decides whether the plot is suitable for the proposed fire station or not. In case the plot is not suitable, then another revision of the plan is requested from the municipality. Therefore re/production of urban physical structure by means of site selecting and designing urban fire stations should be provided within a new process comparing the Current and Proposed Process by means of site selecting and designing urban fire stations in Ankara as seen in the Table 4-1.

**Table 4-1** Comparison of the Current and Proposed Process by means of site selecting and designing urban fire stations in Ankara

| | CURRENT PROCESS | PROPOSED PROCESS |
|---|---|---|
| 1st phase | Decision on zoning as “Municipal Service Areas” or “Urban Administrative Areas” by Municipality | Decision on specifically for Fire Station during the zoning. |
| Response Time increases, fire service quality decreases due to the population growth, sprawling macroform and accessibility deficiencies. | | |
| 2nd phase | Need of improvement on fire service increases. | Less need of improvement on fire service with the help of planned development |
| 3rd phase | Fire Department applies to Municipality for plan revisions | Decision on Fire Station distribution (proposed new FS, relocation, or enlargement) |
| Result | Implementation process takes a lot of time and it can be not satisfactory (For example, in the case of Dikmen after plan revision, the site is still located on a high slope area. | Implementation |

Location and size decisions of the fire station should also be determined so as to allow the maximisation of the area, covered within the targeted response time limits. In order to reach the desired response time targets and improve the level of service, there are flexible and site specific solutions. Coverage area can be revised, fire station area can be enlargeable, fire station can be relocated or new fire stations can be located with the aim of ensuring the satisfactory fire service if necessary.

During the planning of fire stations, cooperation between the neighbouring fire stations and other emergency services such as Emergency Medical Service, Police or Gendarmerie should also be considered in the decisions about the location of the fire stations.

Coverage area is another important indicator influencing the site selection and design of the fire stations. Coverage area depends on the indicators such as the number of annual emergency calls, risk levels and population of the area, type of the station, urban thresholds, distance between the fire stations and targeted response radius.

It is recommended that, fire station's responsibility area should be reduced for the stations receiving more than 1500 emergency calls annually. The response area radius for these stations should be reduced to 3 miles (4.8 km) in order to promote better response times (Spotsylvania County, 2009, p.13-19).

In order to provide satisfactory fire response service as well as the optimal usage of limited public resources; the population of coverage area for one fire station can vary from 1000 to 50000 people according to the reviewed literature. Additionally, distance between two neighbouring stations can be optimised between 1 km and 9 km, according to the literature review.

In addition to the response time and coverage area, there are other indicators influencing the location of the fire stations. The most important of these indicators related to the fire stations are accessibility, building plot form, proximity to junctions or roads and set back distances.

Lack of accessibility increases the average response time. In order to provide a better accessibility, fire stations should not be located over restricted transit roads, such as motorways and tunnels. In case of constraints about this issue, junction points should be preferred, allowing access to all possible directions. It is also recommended to locate a fire station near a controlled and signalised junction because they provide access to all directions with the control of signalisation in case of an emergency.

Form of the plot is another concept influencing the decisions regarding location of fire stations. Locating a fire station on a corner plot is recommended, allowing easy entrance and exit to the station with the design of at least two alternative plans. Plot should also be selected so as to allow the station having direct access to maximum available directions. An example of fire station zoning is presented in the Appendix-I.

Adjacent roads or junctions with high density traffic flow negatively effects the response time of the station and such locations should not be chosen for the fire stations. Fire stations should not be located near the roads or junctions of which levels of service will be between C and F within a planning term.

Additionally, fire response vehicle speed influences the response time and distance between the stations. Heavy water loads on fire response trucks, dramatically decreases vehicle speed, causing higher response time. If fire hydrant systems are built in the city infrastructure, vehicle speed will increase with the help of less water load on trucks, allowing fire stations to be located more distant from each other.

Compatibility of fire stations with the neighbouring land use should also be considered in the site selection decisions. Fire stations should be located away from the educational facility areas, avoiding potential safety issues and disturbance to the educational activities. Distance between the fire station and nearest educational area or land use should be decided so as to provide the desired level of safety and comfort.

Classification of the site selection and design criteria according to the urban scales is very important as it provides a basis towards the implementation of the recommendations mentioned in this thesis. It is important because, the relations between these criteria and the official plans are established by using the standard scales of planning in 1/25000, 1/5000 and 1/1000 scales, corresponding to macro, meso and micro scales respectively.

According to the information obtained from the interview, the metropolitan area as well as responsibility zone of fire response services enlarged as a result of the accelerated urban sprawl due to the Metropolitan Municipality Law numbered 5216. According to Kurutuz and Sarı (2010), current regulations regarding the improvement of fire services due to expansion of cities, are insufficient as there is only a relation between population and total administrative area mentioned in the law. The lack of necessary contemporary standards and criteria in the regulations cause new fire stations to be located and designed by subjective decisions of fire station administrators depending on their personal experiences.

# CHAPTER 5

# CONCLUSIONS & RECOMMENDATIONS

## 5.1. General Conclusions

In conclusion of this research regarding the spatial requirements of fire stations, a set of standards, criteria and recommendations are prepared in order to assist the authorities and urban designers when making decisions about site selection and design of the fire stations. Current legal instruments having unspecialized standards and lack of details, should be upgraded according to the key findings and guidelines mentioned in the results section, ensuring optimal use of land and cost effective fire services providing satisfactory emergency response.

Legal instruments concerning the site selection and size of fire stations are clearly superficial and insufficient, causing subjective implementations to take place depending on the individual experiences of the local authorities when making decisions on setting up or improvement of the current fire service. It is important to minimize subjective decisions by using rational methods such as standards, criteria and also mathematical models which are represented as in the Appendix-II.

By using this guideline, fire stations can be located and designed rationally instead of subjective practises, and they can be considered as an emergency service rather than any administrative facility. It is revealed that the decisions about the site selection and design of the fire stations are related to not only population criterion, but also multi criteria issues in macro-meso-micro scales.

It is necessary to define the requirements for fire station administrations, municipalities, planning and design firms' guidance on what spatial features a new or renovated fire station should be required in urban areas. By putting the needs down in a formal manner, a lot of confusions can be eliminated and a number of areas having similar characteristics where different designers have applied different concepts can be standardized.

Considering Fire Station based Neighbourhood Design, the most important indicator to evaluate the performance of fire services is accessibility in a-four-minute targeted response time. Accordingly the radius of fire station coverage area should be approximately 4 km. and area the distance between two fire stations should be approximately 8 km. regarding the speed of fire vehicles as 60 km/h. In general, central locations and proximity to fire risk zones are preferred. Fire stations should be located on relatively larger plots for additional functions in periphery, and on smaller plots in central areas.

Easy and direct access to main road by locating fire stations away from congested areas/junctions and urban edges is important for quick response. Therefore it is necessary to ensure coordination between traffic signalisations, to control traffic signalisation by the help of dispatch center or from the fire vehicle, to provide enough manoeuvring area in dead-end streets, to arrange traffic islands in order to ensure access to all directions, to prohibit car parking on streets where necessary.

In conclusion of Ankara case study, considering new developments in the south-east part of Ankara, locating at least two more fire stations would be a better strategy rather than the enlargement of existing Çayyolu Fire Station in central area. In addition, especially Türkkonut and Yaşamkent Districts having high rise residential development, require fire stations in order to minimise response time. Also considering the location of Yaşamkent allowing easy access to the ring road, the main arterial Eskişehir Road and the districts Temelli and Bağlıca, the new fire station would be advantageous having relatively larger plot for additional functions such as workshops, educational and sports facilities.

### 5.2. Recommendations for Further Researches

Investigating the spatial requirements of fire stations especially in urban areas, a number of limitations are encountered. These limitations are explained as information and data constraints which are only focused on architectural standards, lack of reliable statistical data, and complexity of the system including the other emergency response services, subjective and superficial legislation and implementation process.

Architectural typological analyses of fire stations, rural fire stations and wildfires, location models, landscape design to ensure fire safety, emergency management, costs and funding are the other issues to be researched in a multi-disciplinary perspective.

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## APPENDIX-I

### HONOR AWARD FOR "ON-THE-BOARDS" FIRE STATION PROJECTS prepared by Atkinson/Dyer/Watson Architects - FD Station No. 39 Charlotte, NC

**Figure I-1** "On-The-Boards" Fire Station Projects Drawings


**Figure I-2** “On-The-Boards” Fire Station Projects Drawings

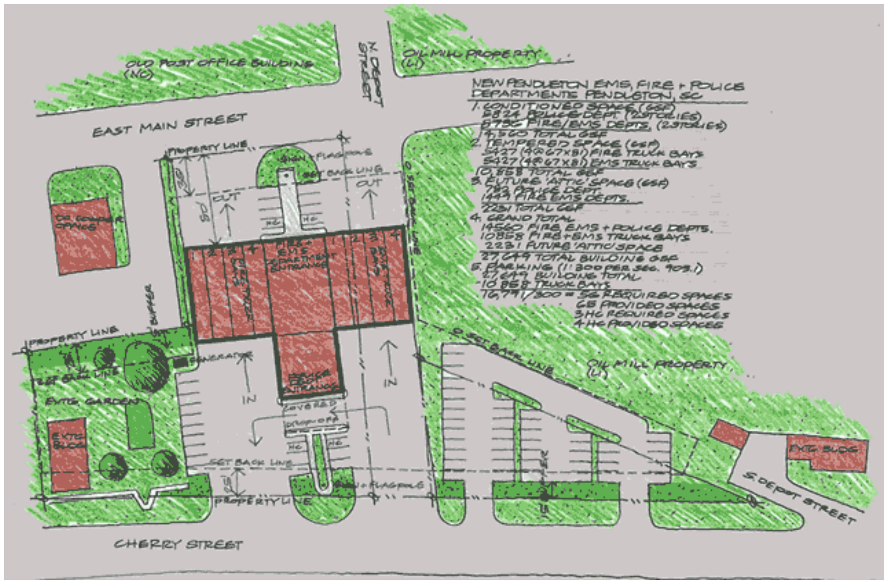


**Figure I-3** “On-The-Boards” Fire Station Projects Drawings

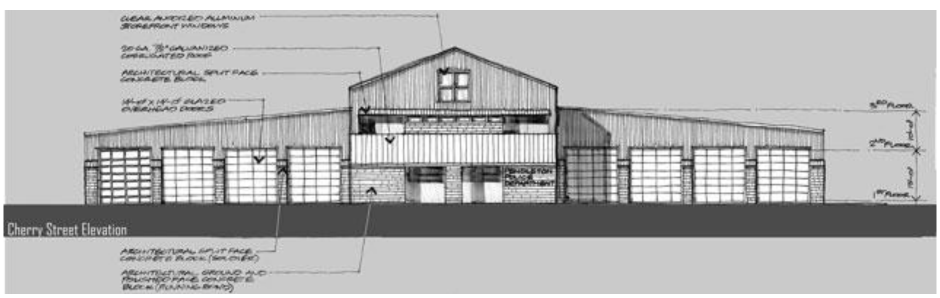


**Figure I-4** “On-The-Boards” Fire Station Projects Drawings

**Figure I-5** “On-The-Boards” Fire Station Projects Drawings

# APPENDIX-II

## AN OVERVIEW OF SOME OF THE LITERATURE TO DETERMINE THE LOCATION OF EMERGENCY FACILITIES (adapted)

**Table II-1** Table of relevant literature of emergency facility location

| | | | |
|---|---|---|---|
| **Works mainly considered the problem of locating emergency resources:** | | | |
| 1973 | Toregas and ReVelle | Location Set Covering Problem (LSCP) | - The aim of the model is deploying emergency service units in an optimal fashion.<br>- The LSCP sought to position a minimum number of fire companies in a manner such that each CFS (calls for service) in the network has at least one fire company within a specified distance or time.<br>- The LSCP has been extended to siting problems in which coverage is required over time, both in a future time context and a time of day context. |
| 1980 | Schilling | Multiobjective Programming Formulation | - Coverage for one period can be traded off against coverage in other periods was demonstrated. |
| 1994 | Repede and Bernando | | It was allowed the number of emergency vehicles (ambulances in this case) to change over the course of a day as demand varied. |
| 1974 | Church and ReVelle | Maximal Covering Location Problem (MCLP) | - It seeks to place a fixed number of fire companies so that the number of CFSs that have a fire company positioned within a certain distance can be maximized.<br>- The LSCP and MCLP formulations assumed that servers are continuously available and do not take congestion into account.<br>(Congestion here refers to the condition that all servers are busy responding to CFSs and an emergency occurs requiring a server to be available immediately). |
| 1974 | Chapman and White | Probabilistic Optimization Models | - Probabilistic optimization models take explicit account of the probabilities of servers being busy and compute the amount of redundancy actually needed.<br>- It was formulated a probabilistic version of the LSCP, where the probability that at least one server is available within a distance to each demand node is required to be greater than or equal to a threshold.<br>(They referred to the probability of a server being busy as the busy fraction). |
| 1983 | Daskin | | Adopting the notion of busy fraction, it was maximized that the expected value of population coverage within a time range, given that $p$ facilities are to be located in the network. |
| 1988 | ReVelle and Hogan | | It was constrained that the level of server availability to a preset value and minimized the total number of servers. |

**Table II-1** Table of relevant literature of emergency facility location

(continues)

| | | | |
|---|---|---|---|
| **Works in the literature investigated the problem of defining response areas for existing and often fixed emergency service units, or the so-called districting problem:** | | | |
| 1972 | Carter et al | | - It was considered that the districting problem when only two fire stations cover a region.<br>- A damage function, which is essentially a performance measure, was defined in the analysis. Travel time was chosen as the damage function in their work. They determined the damage function in terms of the average travel times it took fire companies to respond to the incident from each of the two stations.<br>- The minimum average travel time $E(C)$ was calculated by weighing the difference in the average travel times should any one station respond to all incidents in the region with a given intensity factor (ratio of incident arrival rate to service rate). |
| 1974 | Larson | Hypercube Model | - It was used to solve the districting problem, assuming that only the companies from one fire station respond to an incident.<br>- However, this approach cannot determine how many fire companies need to be dispatched to an incident from a particular station. |
| 1975 | Jarvis | * optimal districting plan | - It was showed that the optimal districting plan in the case of several fire stations is a direct generalization of the results given by Carter et al. (1972) for two fire stations.<br>- The computational complexity of this approach increases exponentially with the number of fire stations rendering this approach intractable. |
| 2004 | Baiyu Ynag, Krishnan Viswanathan, Ponlathep Lertworawanich; and Sendil Kumar) | Fire Study Districting Using Simulation: Case Study in Centre Pennsylvania<br><br>Simulation, Transcad, GIS, mathematical programming | - Due to the limitations of the aforementioned works and advances in simulation and geographic information systems (GIS) technologies, it was decided to solve the districting problem for fire stations in the Centre Region using simulation with the input data prepared by GIS technologies.<br>- While this approach does not provide an optimal solution directly, different scenarios can be easily examined and a satisfactory solution can be chosen from a set of user-specified candidate alternatives.<br>- The objective of this paper is to solve this realworld problem by:<br>• Reducing the average response time to incidents in the Centre Region, and<br>• Balancing the workload of fire stations in order to use the available resources more efficiently.<br>- This work is aimed at practitioners with the goal of providing a practical tool to assist decision making concerning fire department operations. |
| 2009 | Wu and Ren | Research on Urban Fire Risk Comprehensive Evaluation and Its Applications in China | Urban Fire Risk Evaluation Index System and Fuzzy Comprehensive Evaluation Model For Urban Fire Risk (An assesment model for city fire risk is established in this article by applying fuzzy mathematics theory) |

**References of the Table (Appendix II):**


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## APPENDIX-III

## LAYOUTS OF WATERFORD HEADQUARTERS AND SOUTHFIELD FIRE STATIONS

(Adopted from Robert C. Barr and John M. Eversole, The Fire Chief’s Handbook, Sixth Edition, Fire Engineering, 2003, pp.440-445, Oklohoma USA.)

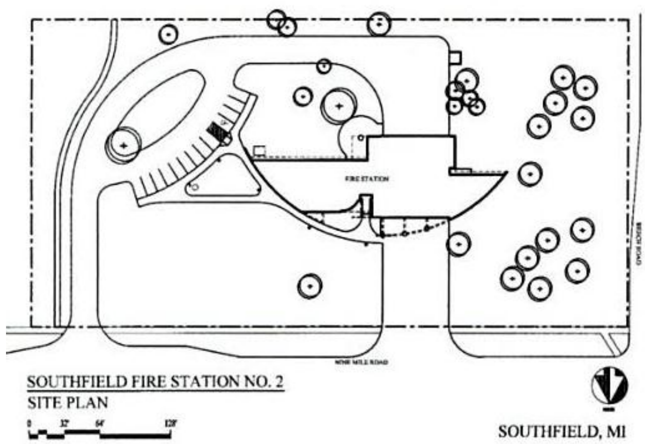



**Figure III-1** Drawing of fire station


**Figure III-2** View of fire station

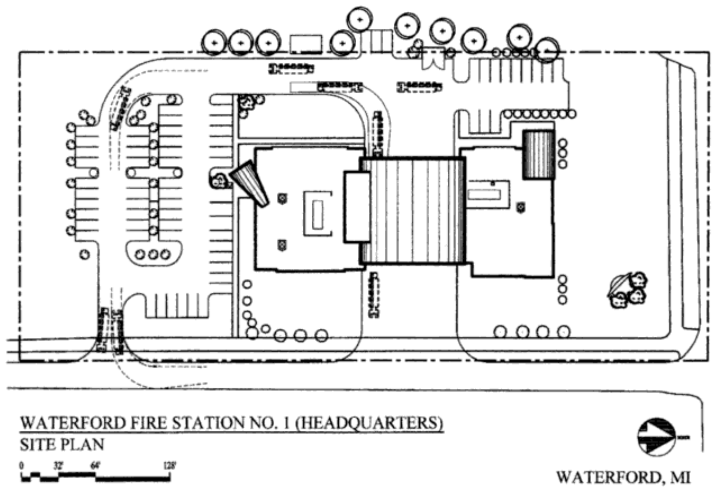



**Figure III-3** Drawing of fire station

# APPENDIX-IV

## THE RELATIONS AMONG AREA, POPULATION AND NUMBER OF FIRE STATIONS

**Table IV-1** Table of relations among area, population and number of fire stations

| Reference | Size of Fire Stations | Population relations |
|---|---|---|
| (Ersoy and Eker cited Önen,Ü; 1980, p.192) | Fire Station (Required Area)<br>average (0,05-0,10 m²/person)<br>minimum (0,10-0,05 m²/person) | **PERSON/AREA**<br>Person/Area |
| (Habibi et al., 2008, p.3308) | It is necessary to allocate for each person 0,3 m² for station and 0,8 for the open space of station when the urban facilities and utilities are planned the least per people which in sum is about 1,0 m². | |
| | | |
| (Ersoy and Eker; 1980, p.189) | Administrative Areas<br>0,20 m²/person (for the district population is 15.000 people);<br>0,40 m²/person (for the group of districts population is 45.000 people) | Person/Area (considering population groups) |
| (Ersoy and Eker cited Önen,Ü; 1980, p.192) | *As a voluntary organization, 0,04m²/person for the settlements having population 25.000 people (according to Feder).<br>* As a voluntary organization, 0,08m²/person for the settlements having population 25.000 people (according to Stuttgart High Technical School).<br>* As a municipal organization, 0,06m²/person for the settlements having population 50.000 people (according to Recherberg).<br>* 0,01m²/person (according to Arckerle).<br>* 0,01 m²/person or the settlements having population 30.000 people (according to Pohl)<br>* As a municipal organization in metropols, 0,03 m²/person (according to Brandt) | |
| Legislation based on Urban Planning Principles (1985, revised in 1999) | For Administrative Areas<br>3 m²/person (Population 0-15.000 people);<br>3,5 m²/person (Population 15.000-45.000 people);<br>4 m²/person (Population 45.000-100.000 people);<br>5 m²/person (Population 100.000+ people) | |
| BIMTAS | For Administrative Areas<br>1,40 m²/person | |

## APPENDIX-V

## THE RELATIONS AMONG PLOT AREA OF AN INDIVIDUAL FIRE STATION, POPULATION AND NUMBER OF FIRE STATIONS

**Table V-1** Table of relations among plot area, population and number of fire stations

| **REFERENCES** | **SIZE OF FIRE STATIONS** | **POPULATION RELATIONS** |
|---|---|---|
| (in Germany, 2_17G p.181; Ersoy, 2009) | 6.000-8.000 m². | **TOTAL AREA**<br><br>Total Plot Area<br><br>-The Size of Plot:<br>- Required Land Area (Lot) Size: |
| (Habibi et. al., 2008, p.3308) | _ The standard area for small sized stations is 1500 m² and for the medium sized stations is 3000 m²<br>_To sitting the station in the concentrated area of the city, the plot size for small sized station should be at least 1000 m²<br>_ 1000-3000 m² for a medium sized station | |
| (Spotsylvania County, 2009, pp.13-19) | - Acquire sites of at least 3 acres in the urban area since there is the availability of county water and sewer lines and 5 acres in the rural area in order to accommodate a drain field with a 100% reserve drain field in order to provide for co-location of public facilities and future expansion.<br>- Buildings should be a minimum of 15.000 square feet in size. | |
| (Queesland Government, 2007, p.94) | Site area (Indicative minimum site requirements)<br>3.000–4.000 m² (auxiliary station)<br>3.000–6.000 m² (permanent station)<br>10.000–20.000 m² (permanent station with specialist facilities attached, e.g. workshops and communication centre). | |
| (EnviroIssues and Juan, 2008, p.6) | Approximately 15.000 square feet (ideal dimensions 120 feet by 130 feet) as needed to accommodate the full program of approximately 8.435 square feet for this particular replacement station (p3).<br>_ the 14.000-20.000 square feet size criteria (to achieve the minimum site requirement) | |
| BBNDA General Development Control Regulation (p.49) | For public buildings and government buildings & institutions, the minimum area/size of plot shall depend on the specific requirements; however it should not be less than 500 m² | |
| (Habibi et al., 2008, p.3308) | _The standard plot for large sized stations with more than 7.500.000 people is 6000 $m^2$ | Total Plot Area (considering population groups) |

# APPENDIX-VI

## COVERAGE AREA- RESPONSE TIME RELATIONS AND OTHER INDICATORS

**Table VI-1** Summary of coverage area- response time relations and other indicators

| REF | COVERAGE AREA | RESPONSE TIME | OTHER INDICATORS |
|---|---|---|---|
| (Habibi et al., 2008, p.3308) | 2000 m. response radius & 40 km/h (to guarantee the quick response) | 3-5 min. | Distance Between Two Stations<br>2500 m. |
| (Wu and Ren, (cited Codes) 2009, p.779) | 4-7 sq km (400-700 hectare) (for fighting dwellings fires) | 5 min. (1 min. for dispatch & turnout, 4 min. for travel) | – |
| (Wu and Ren, (cited Wright) 2009, p.779) | High & Very High Fire Rate Category Areas | 6-10 min. | – |
| | Medium Fire Rate Category Areas | 11-15 min. | |
| | Low Fire Rate Category Areas | 16-20 min. | |
| (Wu and Ren, 2009, p.779) | For Very High Fire Rate Category Areas | 5 min. | Settlement Character<br>Building density<br>Population density<br>Economic density |
| | High Fire Rate Category Areas | 8 min. | |
| | Medium Fire Rate Category Areas | 12 min. | |
| | Low Fire Rate Category Areas | 15 min. | |
| | Very Low Fire Rate Category Areas | 20 min. | |
| | 4 to 7 sq km (400-700 hectare) is too general, besides this the other indicators should be considered | – | |
| (Spotsylvania County, 2009, pp.13-19) | Urban or Suburban Areas | 6 min. | - Size of Fire Station Area according to Settlement Character<br>smaller for urban areas<br>- Coverage Area according to Number of Calls<br>reducing the coverage areas for the stations exceeding 1.500 calls annually |
| | Rural Areas | 8 min. | |
| | Overall Average | 7 min. | |
| | 3-mile (~4,8 km.) radius<br>(inside the Primary Development Boundary)<br>5-mile (~8 km.) radius<br>(outside the Primary Development Boundary) | – | |

**Table VI-VI-2** Summary of coverage area- response time relations and other indicators (continues)

| REF | COVERAGE AREA | RESPONSE TIME | OTHER INDICATORS |
|---|---|---|---|
| (Erkut et al., 2001, p.2) | – | 9 min. (a widely accepted standard for EMS response )<br>5 min. (the goal of the city) | - Demand Points<br>- Fire Station Locations<br>- Travel Distances |
| (Liu et al., 2006, p.361) | Investigations by local authorities revealed that the distance between one fire station and its nearest fire station must be within 1–9 km. | 8 min. (targeted RT)<br>5 min. (proposal of Local authorities)<br>(Maximizing the area that can be served by fire stations within 6 min.) | Distance Between Two Stations<br>a suitable distance |
| (EnviroIssues et. al., 2008, p.3). | – | 4-6 min. (ideal RT) | - Travel Speed<br>- Traffic Volume |

## APPENDIX-VII

## TECHNICAL DETAILS OF FIRE STATIONS IN ISTANBUL

(Data obtained from report by BIMTAS)

**Table VII-1** Table of technical details of fire stations in Istanbul

| FIRE DEPARTMENT | UNIT * | DISTRICT | NUMBER OF PERSONNEL | NUMBER OF VEHICLES | AREA ($m^2$) | | |
|---|---|---|---|---|---|---|---|
| | | | | | OPEN AREA ($m^2$) | BUILDING AREA ($m^2$) | TOTAL AREA ($m^2$) |
| ANATOLIAN | ÜSKÜDAR (D) | ÜSKÜDAR | 64 | 8 | 1840 | 640 | 2480 |
| | ÇENGELKÖY (B) | ÜSKÜDAR | 18 | 1 | 1060 | 360 | 1420 |
| | KADIKÖY (D) | KADIKÖY | 73 | 8 | 7043 | 1957 | 9000 |
| | ERENKÖY (B) | KADIKÖY | 27 | 3 | 450 | 330 | 780 |
| | ADALAR (D) | ADALAR | 47 | 9 | 685 | 265 | 950 |
| | HEYBELİADA (B) | ADALAR | 18 | 3 | 0 | 355 | 355 |
| | KINALIADA (B) | ADALAR | 12 | 2 | 110 | 281 | 391 |
| | BURGAZADA (B) | ADALAR | 12 | 2 | 115 | 200 | 315 |
| | KARTAL (D) | KARTAL | 73 | 10 | 1514 | 1200 | 2714 |
| | ÜMRANİYE (D) | ÜMRANİYE | 75 | 7 | 3000 | 880 | 3880 |
| | PENDİK (D) | PENDİK | 70 | 9 | 200 | 710 | 910 |
| | TUZLA (B) | TUZLA | 24 | 3 | 500 | 990 | 1490 |
| | AYDINLI (B) | TUZLA | 6 | 2 | 50 | 300 | 350 |
| | BEYKOZ (D) | BEYKOZ | 54 | 6 | 1323 | 385 | 1708 |
| | MALTEPE (D) | MALTEPE | 61 | 6 | 0 | 450 | 450 |
| **TOTAL** | | | **634** | **79** | **17890** | **9303** | **27193** |

*District Group (D), Battalion (B)

**Table VII-1** Table of technical details of fire stations in Istanbul (continues)

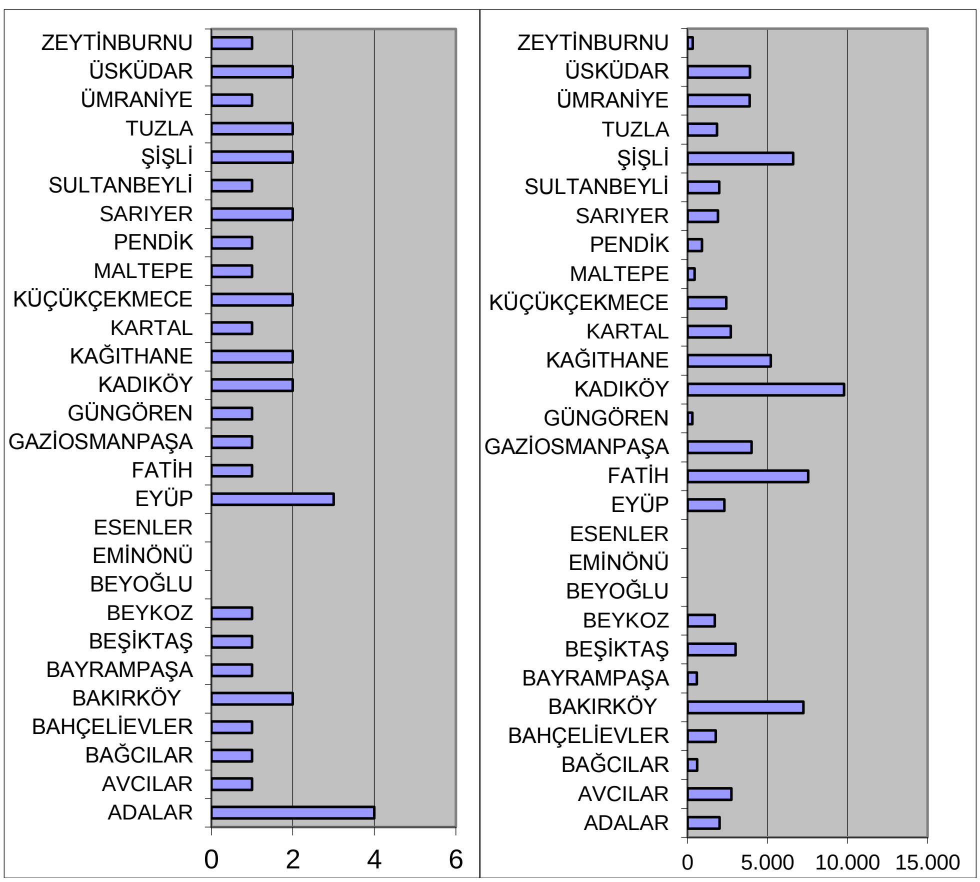
| FIRE DEPARTMENT | UNIT * | DISTRICT | NUMBER OF PERSONNEL | NUMBER OF VEHICLES | AREA ($m^2$) | | |
|---|---|---|---|---|---|---|---|
| | | | | | OPEN AREA ($m^2$) | BUILDING AREA ($m^2$) | TOTAL AREA ($m^2$) |
| THE BOSPHORUS | ŞİŞLİ (D) | ŞİŞLİ | 96 | 11 | 0 | 2308 | 2308 |
| | KAĞITHANE (B) | KAĞITHANE | 24 | 3 | 1950 | 250 | 2200 |
| | KEMERBURGAZ (B) | EYÜP | 9 | 1 | 0 | 0 | 0 |
| | G.PAŞA (D) | G.PAŞA | 94 | 10 | 0 | 4000 | 4000 |
| | ALİBEYKÖY (B) | EYÜP | 18 | 2 | 0 | 500 | 500 |
| | BEYOĞLU (D) | ŞİŞLİ | 74 | 10 | 2000 | 2300 | 4300 |
| | BEŞİKTAŞ (D) | BEŞİKTAŞ | 73 | 8 | 2000 | 1000 | 3000 |
| | SEYRANTEPE (B) | KAĞITHANE | 27 | 5 | 2600 | 400 | 3000 |
| | İSTİNYE (D) | SARIYER | 41 | 5 | 0 | 400 | 400 |
| | SARIYER (D) | SARIYER | 44 | 7 | 500 | 1000 | 1500 |
| **TOTAL** | | | **500** | **62** | **9050** | **12158** | **21208** |
| İSTANBUL | FATİH (D) | FATİH | 116 | 12 | 850 | 6686 | 7536 |
| | BAKIRKÖY (D) | BAKIRKÖY | 112 | 13 | 2000 | 2000 | 4000 |
| | ZEYTİNBURNU (B) | ZEYTİNBURNU | 8 | 3 | 250 | 70 | 320 |
| | YEŞİLKÖY (B) | BAKIRKÖY | 6 | 2 | 3000 | 250 | 3250 |
| | KOCASİNAN (D) | BAHÇELİEVLER | 69 | 8 | 960 | 800 | 1760 |
| | SEFAKÖY (B) | KÜÇÜKÇEKMECE | 27 | 3 | 960 | 760 | 1720 |
| | RESNELİ (B) | KÜÇÜKÇEKMECE | 6 | 2 | 500 | 200 | 700 |
| | BAĞCILAR (D) | BAĞCILAR | 57 | 5 | 200 | 400 | 600 |
| | MERTER (B) | GÜNGÖREN | 30 | 4 | 0 | 300 | 300 |
| | AVCILAR (D) | AVCILAR | 68 | 8 | 750 | 2000 | 2750 |
| | BAYRAMPAŞA (D) | BAYRAMPAŞA | 70 | 8 | 264 | 312 | 576 |
| | EYÜP (B) | EYÜP | 27 | 3 | 1270 | 330 | 1600 |
| **TOTAL** | | | **596** | **71** | **11004** | **14108** | **25112** |
| **OVERALL** | | | **1730** | **212** | **37944** | **35569** | **73513** |

*District Group (D), Battalion (B)

## APPENDIX-VIII:

## NUMBER AND SIZE OF FIRE STATION AREAS ACCORDING TO THE DISTRICTS WITHIN THE ISTANBUL METROPOLITAN AREA

**Figure VIII-1** Charts showing number and size of fire station areas in Istanbul



## APPENDIX-IX:

## INTERVIEW PREPARATION – DECLARATIONS

**Interviewee-1: Faruk KURUTUZ (**Deputy Director of the Fire Department in Metropolitan Municipality of Ankara and General President of Turkish Fire Fighters Association)

<u>Decleration-1:</u>

Mr. Kurutuz said that perception on fire department is still the same with the classical perception of 15-20 years ago. However, they also need chemical and civil engineers at fire scene. Therefore, Metropolitan Municipality of Ankara would employ engineer, architect, city planner, economist, social worker and business man in fire service personnel. He also emphasized that the mentioned staff stayed on fire departments in developed countries even before 20-30 years ago (CHA, 26.06.2009).

<u>Decleration-2:</u>

Mr. Kurutuz states that when a fire call from fire line 110 reach to the fire crew, they complete their preparation in 35-40 seconds and leave for fire. He also states that fire vehicles arrived to the fire scene in 5-12 minutes. The world standards in terms of personnel and equipment are provided by Ankara Fire Station Headquarter (AA, 23.09.2009).

Decleration-3:

Mr. Kurutuz mentioned that fire stations are organized according to settlement structure and necessity of city. Additionally, it is considered to provide collaboration between neighboring fire groups. For instance, to provide the world standards on response time in Ankara, Etimesgut Fire Department Group was established in order to keep the response time in 5-8 minutes in Etimesgut District. Cooperative work with Sincan Fire Group will assist to response more effectively.

Decleration-4:

Mr. Kurutuz declared that considering to topography of the city, 25 fire groups have been deployed in such a manner that fire fighter can efficiently response to probable fires in various districts.

Decleration-5:

Kurutuz, who reminds that organization network is extended by fire department with having regard to new towns in the metropolitan area and structure and transportation connections, stated that they made ready to Ankara Fire Department to service in high level (CHA, 26.06.2009 ; ANKA, 12.09.2009).

Decleration-6:

Kurutuz emphasizes that the number of fires in winter season increases. He also mentions that fires usually happen in urban areas, especially houses, offices, public offices, schools, hospitals, hotels, industry facilities, gas stations and vehicles have a greater risk of fires in winter season (CHA, 06.02.2007).

# APPENDIX-X

## INTERVIEW PREPARATION – QUESTIONS, KEY ISSUES AND DEMAND FOR DATA

Interviewee 1 : Faruk KURUTUZ

Mission : Director of the Fire Department in Metropolitan Municipality of Ankara
General President of Turkish Fire Fighters Association

Interviewee 2 : Yakup SARI (redirected by Faruk Kurutuz)

Mission : Deputy Director of the Fire Department in Metropolitan Municipality of Ankara

Contact Information : Ankara BŞB İtfaiye Dai. Bşk. TurgutÖzalBulvarıNo:İskitler/Ankara

Theme : Fire Station Types, Site Selection and Design Decisions of Fire Stations, Implementation Process in Urban Scale, Technical Criteria and Regulations

Questions, Key Issues and Demand for Data:

1. Is association's opinion asked, when side, type and form of fire stations are determined? (Based on the inscription of "related association's opinion is asked" which is mentioned in construction law.)

How is the process work and how is the construction plan impact? (Official records, planner, directorate of construction affairs, tender, private architectural office etc.)

What type of criterions are available (magnitude, form, tenure, access, distribution of stations in urban area, population, density, properties of structuring, function, use of area, relationships in environmental applications, cooperation between stations etc.)?

Have these notions legal sanction (regulations, guide, standards etc.)?

Is the content of legislations is enough? (Architecture, materials, equipment level, providing public interest, criteria of administrative station area per person, serviced population or number of fire vehicles)

Is there any plan or lay the groundwork for fire/disaster scenarios in various qualities?

Classification of Urban Areas in Respect of Fire Risk Groups, Distances between Units according to these groups

What kind of necessities do you have?

How is the qualification of delivering service determined?

How the growing of city and extension of boundaries are affect the capacity of service?

Which areas are available to reach in critical time?

What are the worldwide studies, used methods, mathematical/spatial models and standards at this matter?

<u>2a. Classification of Fire Stations (Typology of Fire Stations)</u>

- Capacity
- Area/Types of Structure
- Service Type/Function

<u>2b. Relationship of Fire Stations and Urban Area</u>

- Site Selection/Distribution in City (urban or sub-urban area; residential area, CBD or historical city centre; metropolitan area, district or neighbourhood level)
- Other strategic services/ Emergency Response Units (police, first aid, rescue, civil defence etc.)
- Relationship with neighbour fire brigade etc. (Distances between two fire brigade/service units and relationship between them)

- Response time, responsibility zones (Relationship of transportation network, traffic conditions)

- Size of stations, Range of station service area

- Relationship with surrounding land use

- Spatial attributes of station plots

3. Demand of Data

- Sample of Association Notion Document

- Sample of Report of fire response (in a content which can be useful for problem detection, for instance a case on an accessibility problem)

- Spatial Studies in urban scale, research, publications etc. on Fire and Rescue Stations for design and location

- Related regulations, standards, criteria

- Any research on the comparison of values with the other cities and countries

- Any studies of performance assessment

- Any documents on Fire Stations Types, project samples, etc.

## APPENDIX-XI

## SEATTLE FIRE DEPARTMENT’S SITING STUDY FOR FIRE STATION-20

**Table XI-1** Review of sites

**REVIEW OF SITES**

**(A short list sites considered as potential alternate sites for relocation of Fire Station 20 or as an alternate to these sites, Fire Station 20 is considered to stay at its current location by enlarging the existing site…)**

| SITE | CODE | PROS | CODE | CONS | CODE | RECOMMENDED ADDITIONAL ANALYSIS | SITE SPECIFIC COMMENTS |
|---|---|---|---|---|---|---|---|
| **The Interbay Golf site** | P1 | suggested by the community | C1 | SFD (Seattle Fire Department) has expressed concerns about locating a station on a busy arterial such as 15th Avenue W. | R1 | The independent team recommends that geotechnical and soils reports as well as an environmental report be completed. | _Site is restricted to park use by Initiative 42, any removal of land from park use must be offset by acquiring a like amount of land in the area for equivalent or better park purposes. |
| | P2 | consistently performed at a high level throughout modeling. | C2 | Geographic Information System (GIS) data indicates that this site is on a mix of artificial fill and landfill debris. | R2 | Additionally, site improvement costs and the verification of the constraints of Initiative 42 should be researched. | |
| | P3 | a City-owned property | C3 | This site is also on the eastern border of the Interbay liquefaction zone. | | | |
| | P4 | not adjacent to residential housing | C4 | Additionally, Initiative 42, which protects Seattle’s parks, may present certain limitations. (Site is restricted to park use by Initiative 42, any removal of land from park use must be offset by acquiring a like amount of land in the area for equivalent or better park purposes) | | | |
| | P5 | uses W. Armour Street to access 15th Avenue W. | | | | | |
| | P6 | a large site | | | | | |
| | P7 | a flat site | | | | | |
| | P8 | a corner lot | | | | | |
| | P9 | currently underutilized as a parking area. | | | | | |
| | P10 | While there are few arterials similar to 15th Avenue W.,modeling of 2007 response data for SFD fire stations 18, 31, and 35 – all located on arterials –demonstrated that effective response levels can be achieved on or near major transportation corridors. | | | | | |
| | P11 | Adding signal controls to the existing traffic signal at the intersection 15th Avenue W. and W. Armour Street (adjacent to the Interbay Golf site) could allow apparatus to quickly and safely access both north and south bound lanes on 15th Avenue W. | | | | | |
| | | | | | | | |
| **Seattle City Light** | P1 P2 P3 P4 | * | C3 | located in the heart of Interbay in a designated liquefaction zone. | R1 | * | _This site has an intended future use for utility infrastructure. While not currently used for electrical purposes, City Light acquired the property stating it is necessary for future use as a substation to accommodate growth in the area. City Light indicated that other site options were limited and it is not surplus. |
| | P12 | a large, relatively flat corner lot and is currently vacant | C5 | may be the future site of a substation | R2 | Additionally, site improvement costs and the verification of City Light’s intent for this property should be researched (This site has an intended future use for utility infrastructure. While not currently used for electrical purposes, City Light acquired the property stating it is necessary for future use as a substation to accommodate growth in the area. City Light indicated that other site options were limited and it is not surplus). | |
| | | | C6 | not located at a signalized intersection. | | | |
| | | | | | | | |
| **Northwest Label** | P13 | the only site that is not located in an environmentally critical area | C7 | currently occupied by an existing business | R1 | … | _At 12.000 square feet, this site fails to meet the 14.000-20.000 square feet size criteria. Because of the how the adjacent property is used, this site could require the acquisition of two additional parcels of land in order to achieve the minimum site requirement.<br>_Site is adjacent to residential property. |
| | P8 | * | C8 | small (At 12.000 square feet, this site fails to meet the 14.000-20.000 square feet size criteria. Because of the how the adjacent property is used, this site could require the acquisition of two additional parcels of land in order to achieve the minimum site requirement.) | R3 | site improvement costs and real estate appraisal and acquisition would need to be researched. | |
| | P5 | located on Gilman Avenue W. Which provides direct access to W. Dravus St. | C6 | located at a non-signalized intersection | | | |
| | P14 | provides Magnolia residents with a second station to assist Fire Station 41 in case of a major earth event or emergency. | C9 | access from this site to the eastern portion of the response area could be limited if a major earth event occurred and roads and bridges were compromised | | | |
| | | | C10 | Site is adjacent to residential property. | | | |
| | | | | | | | |
| **Fire Station 20 at current location** | P6 P7 P8 | a large site, a relatively flat site, a corner lot | C11 | was strongly opposed by the surrounding community (expanding the site would require purchase of existing single-family homes) | R1 | * | _Current site is located in a potential slide area with a site cross slope of approximately 10 percent. |
| | P5 | direct access to W. Dravus St. which allows quick access to the service area. | C8 | The existing site is too small to accommodate an improved station. | R3 | * | |
| | | | C6 | * | R4 | Further architectural study to see if station requirements can be met with two additional lots (rather than three) is also recommended. | |
| | | | C3 | in or adjacent to an environmentally critical area (steep slope/slide prone area) | | | |

* The definition of the codes are the same as the codes above.

CRITIC-1 Response Capability and Time Impacts: The consultant’s rating system weights response times –saving lives and property- equally with neighbourhood compatibility. Their current weighting system deducts only one point for every thirthy seconds added to the response time, which minimizes the life safety issue associated with degradation of

CRITIC-2 Risk, Hazard, Value and Protection Analysis: The Risk, Hazard, Value and Protection (RHVP) analysis is disconnected from the site evaluation process discussed elsewhere in the report. It is not clear what relevance this has to the rest of the report. There is no explanation of where the percentage distributions for risk, hazard, value and protection

CRITIC-3 Scoring and Modeling Methodology: There are concerns with the scoring and modeling methodology. For example, it appears that factors such as turns and road impedances are being counted twice.

**SOURCE:** Adapted from Fire Station 20 Siting Study Final Report • August 29, 2008, Prepared by: EnviroIssues, Entrada/San Juan, New Ventures Group, VIA Architecture.

## APPENDIX-XII

## SPATIAL REQUIREMENTS OF FIRE STATIONS ACCORDING TO THE URBAN SCALES

**Table XII-1** Spatial requirements of fire stations according to the urban scales

| SPATIAL REQUIREMENTS OF FIRE STATIONS ACCORDING TO THE URBAN SCALES WITHIN THE URBAN CONTEXT | | | | | |
|---|---|---|---|---|---|
| **URBAN SCALE** | **SCALES WITHIN THE DEVELOPMENT LAW** | **URBAN SPACE** | **RELATIONS TO FIRE RESPONSE** | **INDICATORS** | **SPATIAL REQUIREMENTS OF FIRE STATIONS** |
| **MACRO** | 1/25000 > | CITY | ALL COVERAGE AREAS | Size | Fire stations' area per person varies from 0,01 to 0,10 square meter per person , with a minimum value of 0,03 square meters for metropolis. |
| | | | | | When the ratio of total fire station area given in the literature, to the total administrative area defined in the legislation is evaluated, it is found that minimum 6 ‰ per cent of the administrative area is allocated for fire stations in Turkey. |
| | | | | Response Time | Average response time lower than 5 minutes can be accepted as a targeted response time goal for urban fire stations. In order to lower the response time, distance between fire stations should be lower spatially. |
| | | | | | Targeted response time values can be chosen different than 5 minutes according to the coverage area character and the risk groups within it. |
| | | | | | Urban pattern can have an impact on locating fire stations, for instance in a gridal urban pattern response time reduces. In such urban tissues, distance between fire stations can be increased as well as ensuring desired response time limits. |
| | | | | Coverage Area | Suggested distance between nearest stations should be between 1-9 km considering economical and safety issues. |
| | | | | | Between 2000-40000 people under the coverage of a fire station are accepted as a reasonable population considering the optimal usage of restricted public resources. |
| | | | | | Fire station receiving emergency calls more than 1500 per year should reduce its responsible coverage area |
| | | | | | Locating stations which provide coverage to the greatest percentage of population and area, with the least amount of overlapping of service areas in order to provide optimal usage of limited public resources |
| | | | | Accessibility | Fire stations should not be located over restricted transit roads, such as motorways, tunnels etc. |
| | | | | Future Needs and Extentions | Planning for any potential expansion and to design for the changing nature of work, service type, new facilities, etc. |
| | | | | Cooperation | Clustering service and functional uses for example, combining fire, police, health, and administrative functions |
| | | | | Thresholds | Fire stations should be located on or close to main arterials, but outside of areas that experience high volumes of traffic congestion, as well as disruption caused by train movements |
| **MESO** | 1/5000 | DISTRICT OR NEIGHBOURHOOD | COVERAGE AREA | Accessibility | Fire stations should have direct and quick access to the major arterial with more than 22 m. width or sub arterial road to avoid any traffic congestion |
| | | | | | Not being located on a very busy arterial with travel speeds in excess of 40-45 mph (approximately 65-70 km per hour) |
| | | | | | Not being located near the roads or junctions of which levels of service defined by HCM will be between C and F within a planning term for not suffering from dramatic increase in response time caused by the lagging fire engines in traffic jam |
| | | | | | Locating a fire station near a controlled and signalised junction |
| | | | | | Entering the major street from the side street is facilitated by traffic signals controlled from the station, apparatus or dispatch centre |
| | | | | | Accessing with various modes of public travel to the fire station should be considered for public interaction. |
| | | | | Compatibility with adjacent land use | Being located away from the educational facility areas in order to avoid safety problems, interruptions on educational activities or undesired behaviours through interaction of students. Distance between the fire station and nearest educational area or land use should be determined ensuring the desired safety and comfort |
| | | | | | Not locating in the Special Uses Zone, including special public and private activities of an institutional or open character. |
| | | | | | Not locating in adjacent with preventive factors like gardens, agricultural lands, hills and so on, as it decreases the level of station reflex |
| | | | | | Co-locating fire and rescue facilities for maximum efficiency with other public facilities as well. (Consider including a training room for 50-100 persons in the design of new fire/rescue facilities unless there is a similar public facility available for the surrounding community.) |
| | | | | Thresholds | Distance between stations should be decreased when there exists topographical thresholds, such as in the urban areas having high slope in the streets more than 10 per cent grade |
| | | | | | Leaving the station area and serving as many locations as possible following an earthquake led to a siting requirement that stations be located away from liquefaction wherever possible |
| | | | | | Accessing from the fire station site to the any portion of the response area could not be limited if a major earth event occurred |
| **MICRO** | < 1/1000 | BUILDING PLOT | FIRE STATION SITE | Size | Size of fire stations is defined according to variable issues such as population or population groups, settlement characteristics, types of fire stations, equipment, staff, and vehicles within the fire stations. |
| | | | | | The recommended plot size varies between 1000-20000 square meters, for permanent fire stations is between 3000 to 6000 square meters. |
| | | | | Accessibility | Not locating in the corner or adjacent to the crossroads where there are traffic congestions |
| | | | | | Corner plot can be chosen, allowing easy entrance and exit with at least two alternative access points |
| | | | | | Entrances for apparatus bay and private car parking should be designed separately |
| | | | | | Not being located in one sided or parallel routes, as the lack of connectivity in local and one sided streets decreases the access of the stations |
| | | | | | Plot should also allow the station having direct access to maximum available directions |
| | | | | | Placing stations mid-block on side streets where entering the street is easiest |
| | | | | | Not locating a car parking on the street on which the entrance of the station also located |
| | | | | | Providing safe manoeuvrability on site and adjacent streets, to avoid vehicle structural stress, and for timely operation of apparatus and equipment should be required by relatively flatter location and enough area to manoeuvre. |
| | | | | Future Needs and Extentions | Accommodating reserve apparatus, emergency medical units and refund area for future growth |
| | | | | Compatibility with adjacent land use | Allocating specific plot of land for the rescue near the stations in the case of any incident and in usual time can be used as green space |
| | | | | | Facilities are required to shield neighbouring structures from headlights, sirens, truck noise, emergency lighting etc. and by use of shrubbery |

# APPENDIX-XIII

## MEASURED AND AVERAGE DISTANCES BETWEEN NEIGHBOURING FIRE STATIONS ACCORDING TO THEIR LOCATIONS IN ANKARA

**Table XIII-1** Distance between stations

| Urban Core | Distance to near stations (km) |
|---|---|
| Kurtuluş - Hisar* | 1,42 |
| Kurtuluş - Esat | 2,48 |
| Kurtulus - Headquarters | 3,80 |
| Kurtulus - Asti | 4,80 |
| Asti - Esat | 5,02 |
| Kosk* - Esat | 1,91 |
| Altınpark - Siteler | 2,72 |
| Altınpark - Headquarters | 3,47 |
| Asti - Headquarters | 4,40 |
| Altinpark - Kecioren | 3,96 |
| ***Average Distance Between Stations:*** | ***3,40*** |

*Hisar and Kosk are not main stations

| Urban Periphery | Distance to near stations (km) |
|---|---|
| Kecioren - Pursaklar | 4,93 |
| Headquarters - Batikent | 8,82 |
| Siteler - Kayas | 6,57 |
| Batikent - Etimesgut | 7,53 |
| Etimesgut - Sincan | 7,58 |
| Etimesgut - Cayyolu | 6,63 |
| Çayyolu - Golbasi | 13,49 |
| Golbasi - Kosk* | 10,30 |
| Pursaklar - Kuzey Ankara | 6,81 |
| ***Average Distance Between Stations:*** | ***8,10*** |

*Hisar and Kosk are not main stations

**Table XIII-1** (Continues)

| Outer Districts | Distance to near stations (km) |
|---|---|
| Temelli - Cayyolu | 27,68 |
| Ayas - Sincan | 21,60 |
| Kazan - Sincan | 25,56 |
| Kayas - Elmadag | 23,87 |
| Kuzey Ankara - Akyurt | 12,09 |
| Kuzey Ankara - Cubuk | 18,55 |
| Kalecik - Elmadag | 24,64 |
| ***Average Distance Between Stations :*** | ***22,00*** |

# APPENDIX-XIV

## DETAILED LOCATION AND ADDRESSES OF FIRE STATIONS IN ANKARA UNDER THE RESPONSIBILITY OF ANKARA METROPOLITAN MUNICIPALITY

**Table XIV-1** List of Fire Station in Ankara

| Fire Station | Address |
|---|---|
| Central Fire Department – Headquarters | Turgut Ozal Bulvari No: 9 Altindag |
| Esat Fire Station | Bulbul Deresi Street No:128 Cankaya |
| Kurtulus Fire Station | Celal Bayar Bulvari No:11 Altindag |
| Sincan Fire Station | Ayas Street No: 9 Sincan |
| Golbasi Fire Station | Sanayi Street No:9 Gölbasi |
| Kecioren Fire Station | Kizlarpinari Street No: 90 Keciören |
| Siteler Fire Station | Altinay Street No: 62/A Siteler |
| Hisar (Kale ici) Fire Station | Ichisar Ali Taskin Sk. No: 36 Altindag |
| Altinpark Fire Station | Altinpark Icerisi Altindag |
| Kayas Fire Station | Samsun Yolu Yesilöz Mah. Altindag |
| Cayyolu Fire Station | Ankaralilar Cad. Jandarma Karakolu Yani Yenimahalle |
| Batikent Fire Station | Ostim Alinteri Bulvari No:220 Yenimahalle |
| Akyurt Fire Station | Polis Karakolu Yani Akyurt |
| Temelli Fire Station | Belediye Garaji Icerisi Temelli |
| Kosk Fire Station | Cumhurbaskanligi Kösku Icerisi Cankaya |
| Elmadag  Fire Station | Elmadag Merkez Elmadag |
| Kalecik Fire Station | Eski Terminal Icerisi Kalecik |
| Asti Fire Station | Asti Terminal Icerisi Asti |
| Kazan Fire Station | Fen Isleri Icerisi MezbahaYani Kazan |
| Bala Fire Station | Belediye Garaji Icerisi Bala |
| Etimesgut Fire Station | Etimesgut Aski Icerisi Etimesgut |
| Pursaklar Fire Station | Belediye Garaji Icerisi Pursaklar |

**Table XIV-1** List of Fire Station in Ankara (continues)

| Fire Station | Address |
|---|---|
| Cubuk Fire Station | Cumhuriyet Mah. Cengiz Topel Cad. No:20 Cubuk |
| Ahiboz Fire Station | Konya Yolu 45. Km |
| North Ankara Fire Station | Havaalani Yolu Uzeri |
| Ayas Fire Station | Ferhah Faki Garaji Icerisi Ayas |

[Retrieved from "http://www.ankara-bel.gov.tr/AbbSayfalari/hizmet_birimleri/Itfaiye/gruplarimiz.aspx" on 06.10.2010]

## APPENDIX-XV

## COMMON INDICATORS OF FIRE STATISTICS IN THE LARGEST CITIES OF THE WORLD IN 2004 YEAR

| N | City | Population thous.inh. | Area sq.km. | Total number of: | | Number of fire deaths | Average number of: per 1000 inh. | | Average number of fire deaths | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | calls | fires | | calls | fires | per 100000 inh. | per 100 fires |
| № | Город | Население, тыс.чел. | Площадь территории, кв. км. | Общее число: | | Число погибших при пожаре | Ср.число на 1000 чел. | | Ср.число погибших | |
| | | | | выездов | пожаров | | выездов | пожаров | на 100000 чел | На 100 пожаров |
| Lfd. № | Stadt | Einwohner in 1.000 | Fläche des Stadtgebietes in qkm | Gesamtanzahl: | | Anzahl der Brandtoten | Mittelwert je 1.000 Einw. | | Mittl. Brandtotenzahl | |
| | | | | Einsätze | Brände | | Einsätze | Brände | je. 100.000 Einw. | je 100 Brände |
| 1 | Rio de Janeiro | 12000 | - | 211045 | 14682 | - | 17,6 | 1,2 | - | - |
| 3 | Moscow | 10500 | 1078 | 62014 | 10839 | 456 | 5,9 | 1,0 | 4,3 | 4,2 |
| 4 | New-York | 8008 | 790 | 456696 | 50155 | - | 57,0 | 6,3 | - | - |
| 5 | London | 7429 | 1600 | 115231 | 40539 | 57 | 15,5 | 5,5 | 0,8 | 0,1 |
| 6 | Paris | 6194 | 759 | 415868 | 16062 | - | 67,1 | 2,6 | - | - |
| 7 | Hoshimin | 5286 | 2095 | - | 329 | 14 | - | 0,1 | 0,3 | 4,3 |
| 8 | St. Petersburg | 4520 | 1400 | 41707 | 8300 | 256 | 9,2 | 1,8 | 5,7 | 3,1 |
| 9 | Ankara | 3500 | - | - | 2396 | 3 | - | 0,7 | 0,1 | 0,1 |
| 10 | Berlin | 3390 | 892 | 284885 | 7646 | 44 | 84,0 | 2,3 | 1,3 | 0,6 |
| 11 | Athens | 3193 | 306 | 19469 | 9056 | 11 | 6,1 | 2,8 | 0,3 | 0,1 |
| 12 | Madrid | 2980 | 607 | 24600 | 8755 | 2 | 8,3 | 2,9 | 0,1 | 0,0 |
| 13 | Hanoi | 2900 | 921 | - | 200 | 6 | - | 0,1 | 0,2 | 3,0 |
| 14 | Kiev | 2642 | 780 | 12519 | 3452 | 72 | 4,7 | 1,3 | 2,7 | 2,1 |
| 15 | Tashkent | 2164 | 300 | 17154 | 1610 | 28 | 7,9 | 0,7 | 1,3 | 1,7 |
| 16 | Budapest | 1705 | 525 | 10569 | 3214 | 25 | 6,2 | 1,9 | 1,5 | 0,8 |
| 17 | Haifon | 1673 | 1503 | - | 65 | 2 | - | 0,0 | 0,1 | 3,1 |
| 18 | Vienna | 1627 | 415 | 41704 | 5415 | 12 | 25,6 | 3,3 | 0,7 | 0,2 |
| 19 | Warsaw | 1609 | 517 | 13375 | 6076 | 91 | 8,3 | 3,8 | 5,7 | 1,5 |
| 20 | Sofia | 1221 | 1311 | 5166 | 2816 | 16 | 4,2 | 2,3 | 1,3 | 0,6 |
| 21 | Dublin | 1122 | 356 | 91194 | 10522 | 7 | 81,3 | 9,4 | 0,6 | 0,1 |
| 22 | Berne | 955 | - | 5930 | 1905 | - | 6,2 | 2,0 | - | - |
| 23 | Vientjan | 800 | 160 | - | 37 | 4 | - | 0,0 | 0,5 | 10,8 |
| 24 | Zagreb | 770 | 640 | 2707 | 1469 | 8 | 3,5 | 1,9 | 1,0 | 0,5 |
| 25 | Stockholm | 765 | 187 | 6094 | 2527 | 2 | 8,0 | 3,3 | 0,3 | 0,1 |
| 26 | Riga | 734 | 307 | 8013 | 2861 | 40 | 10,9 | 3,9 | 5,4 | 1,4 |
| 27 | Danang | 687 | 1256 | - | 78 | 1 | - | 0,1 | 0,1 | 1,3 |
| 28 | Helsinki | 559 | 686 | 175543 | 849 | 11 | 314,0 | 1,5 | 2,0 | 1,3 |
| 29 | Vilnius | 553 | 401 | 3130 | 2024 | 20 | 5,7 | 3,7 | 3,6 | 1,0 |
| 30 | Oslo | 522 | 454 | 7723 | 1192 | 4 | 14,8 | 2,3 | 0,8 | 0,3 |
| 31 | Tallinn | 400 | 156 | 13470 | 3510 | 14 | 33,7 | 8,8 | 3,5 | 0,4 |
| 32 | Zurich | 310 | 88 | 898 | 587 | - | 2,9 | 1,9 | - | - |
| 33 | Lubljana | 267 | 275 | - | 1356 | 0 | - | 5,1 | 0,0 | 0,0 |
| **Total/Итого/Gesamt** | | **90985** | **20765** | **1835659** | **220524** | **1206** | **20,2** | **2,4** | **1,3** | **0,5** |

Reference: Brushlinsky, N.N., et al. (2006). Fire statistics. Moscow: International Association of Fire and Rescue Services - Center of Fire Statistics, Report No:11, p.6.

## APPENDIX-XVI

## NUMBER OF REQUIRED VEHICLES BY THE REGULATION AND CURRENT SITUATION IN ANKARA FIRE DEPARTMENT IN 2010

**Table XVI-1** List of vehicles in fire stations

| | Minimum number of required vehicles by the Municipality Fire Department Regulation (2006) | Number of current vehicles (October2010) |
|---|---|---|
| Fire extinguishing vehicle | 36 | 56 |
| Fire extinguishing vehicle (for narrow roads) | - | 12 |
| Water tanker | - | 15 |
| Small water vehicle | - | 1 |
| Snorkel equipment | - | 6 |
| Snorkel equipment – 90m | - | 1 |
| Vehicle with ladder | 12 | 6 |
| Commanding bus | - | 1 |
| Foam tower | - | 1 |
| Emergency rescue vehicle | 9 | 6 |
| Multi-functional rescue vehicles | 10 | 5 |
| Ambulance | 11 | 5 |
| Navigator vehicle | - | 3 |
| Double cabin pick-up | 11 | 20 |
| Service vehicle | 9 | - |
| Demolition vehicle | - | 7 |
| Lighting equipment | - | 2 |
| Fuel tank | - | 1 |
| Excavator | - | 1 |
| Tanker truck | - | 6 |
| Fuel tanker truck | - | 1 |
| Construction vehicle | - | 1 |
| Van | - | 2 |
| Underwater rescue equipment | - | 1 |
| TOTAL | 98 | 159 |

[http://www.ankara-bel.gov.tr/AbbSayfalari/hizmet_birimleri/Itfaiye/ mufrezelerimiz_ve_arac_filomuz.aspx, retrieved on 30.10.2010]