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EVALUATION THROUGH CONSISTING OF COMPONENT MARKET FOR COLD FORMED STEEL FRAMING SYSTEM IN THE FIELD OF LOW-RISE RESIDENTIALS IN TURKEY

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ABSTRACT

Due to the fact that being majority of existing housing stock 1 to 3 storey, production of low rise residentials has still significiant rate in Turkish construction industry. Having been evaluated existing housing stock, quantitative and the qualitative housing projection through near future, demand is continuing for low-rise residentials and cold formed steel framing seems as an alternative to meet the trend of industry-specific. Cold form steel framing system comes into prominence when industrialized systems, which can be used in the field of low-rise residentials in Turkey as prefabricated reninforced concrete stick system, timber frame platform system and cold formed steel frame platform system, are compared in terms of design, production and installation. Cold formed steel framing system had started to be used after 1999 İzmit earthquake with getting know-how from North America. Ten years passing on earthquake, number of firms, serving in variety levels at the phase of design, production and installation, increased. Producer' s of galvanized profiles for cold form steel framing produce similar components as quality and dimensions in Turkey with using North American' s codes and specifications during production phase which is the difficult phase as organizational among the phases of design, production and installation. Having been cold formed steel framing industry' s potential of open building in the field of low-rise residential in Turkey by availability of components in the market, studies are required through consisting of constructional component market. Cold formed steel framing system can be designed as the concept of open building with limited defined component by using a common convention shown on a system catalog.

Keywords: Cold Formed, Open Building, Component

INTRODUCTION

Having been evaluated existing housing stock through low rise housing projection through near future, demand is continuing for low-rise residential. Due to the fact that being majority of existing housing stock is low rise (1 to 3 storey) and less than 150 sqm in terms of building floor area, technological limitations of cold formed steel framing system match with existing housing preferences.

Concern of methods of rapid construction has increased at Turkish construction market after solving financial problem with low rate bank credits. Cold form steel framing system is much more prefered among industrialized systems, which can be used in the field of low-rise residentials in Turkey, in terms of properties of design, production and installation by developer and contractor.

Cold formed steel framing system had started to be used after 1999 İzmit earthquake with getting know-how from North America and ten years passing on earthquake, number of firms, serving in variety levels at the phase of design, production and on site installation, increased. Producer' s of galvanized profiles produce similar components as quality and dimensions in Turkey with using North American' s codes and specifications during production phase which is the difficult phase as organizational among the phases of design, production and installation.

Component types are defined according to existing production inventory, through consisting of component market as natural medium of open building. Cold formed steel framing system catalog can be presented to manufacturer and designer by using a common convention shown on a system catalog with limited defined component and being seperated design and production phase.

PREFERENCE‘ S REASONS OF COLD FORMED STEEL FRAMING SYSTEM BETWEEN INDUSTRIALIZED SYTEMS IN TURKEY

Cold formed steel framing system, known as only “American house“ and “eartquake resistant light constuction system“ in Turkish construction market, is objectively compared with industrialized systems which can be used in the field of low-rise residentials. Design data‘ s of comparision project are obtained from existing housing stock and housing projection through near future.

80% of buildings is residential and 85% of residentials has three and four bedroom in Turkey according to existing housing stock . Average residential floor area is less than 150 sqm as 147 sqm. The reason of this is appliance of 1% VAT for the residentials less than 150 sqm floor area, 18% VAT for the residentials more than 150 sqm floor area. Evaluated as construction technic and number of storey; 98,3% of buildings is R.C construction and 85% of building is 1-3 storey. 32.448 unit (approx. 6,4%) are defined as house among 510.080 residentials which have construction permit in 2005. If a building has more than 4 storey (including ground floor), elevator is obligatory according to building regulations. Low rise buildings are prefered without elevator and less than 4 storey (including ground floor), because of elevator increases construction cost. Design data‘ s belong to comparision project are presented at Table 1 according to existing housing stock and building regulations in Turkey.

Table 1. Design data‘ s

CITY	TOTAL LAND AREA	UNIT LOT AREA	TOTAL HOUSE UNIT	UNIT BUILDING FLOOR AREA	STOREY	UNIT BUILDING FLOOR SPACE	BUILDING TYPE	RESIDENT /HOUSE	DENSITY (resident /hectar)	EAVES HEIGHT (h)
ISTANBUL	11.106 m2 (~ 1 hectar)	430 m2	24	74 m2	2	148 m2	DETEACHED	4	86 (low density)	6.50 m

Prefabricated R.C stick system, timber frame platform system, cold formed steel frame platform system are compared on a typical project in terms of structural system properties, component properties, production properties, installation properties, mounting properties and building cost.

Because of preferences much more in the field of low rise residential rather than panel or celluler systems, stick system is applied as prefabricated R.C system at comparision project. Similarly, reason of much more preferences, platform frame system as stud-floor joist connection is applied as timber frame and cold formed steel frame systems at comparision project.

Three structural system can be applied over choosed single layout and so, objective and fair comparision is aimed with anticipating not to be effected architectural layout by the difference of structural system. (Figure 1)

In order to compare structural systems objectively, insulation layers of three structural system have to supply same conditions of building comfort due to exisiting building and residential regulations.

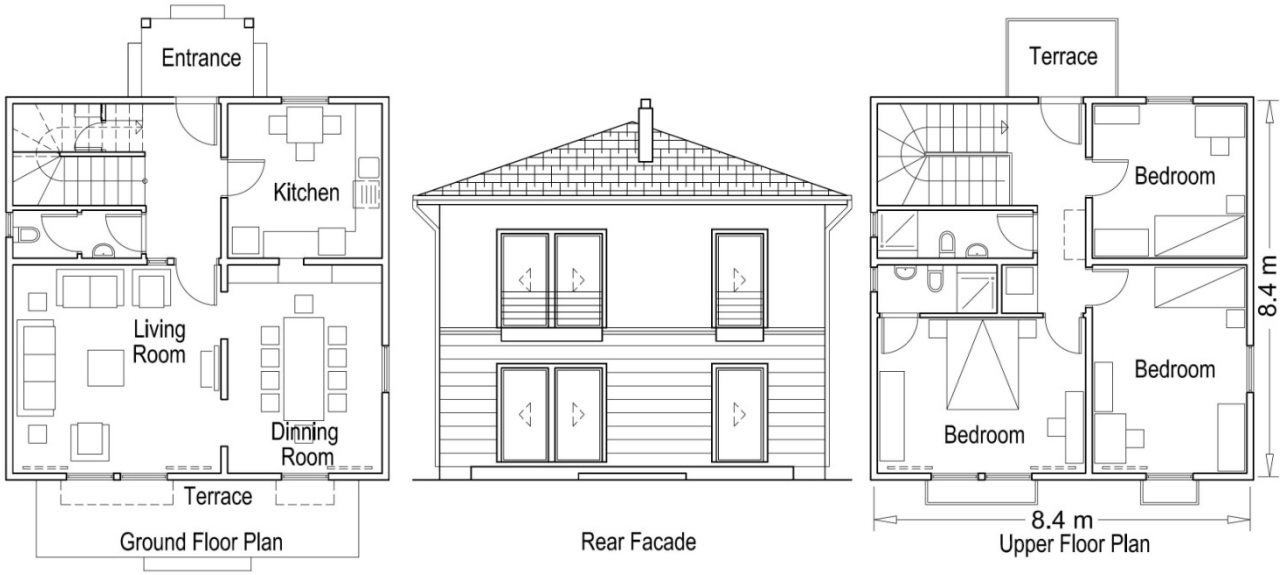


Figure 1. Typical project for comparision of structural systems

Having been lightweight material, obtained directly over stock as a constructional component and available widely at construction market, reinforced gas concrete panels are prefered at walls and floors at prefabricated R.C stick system. 20 cm thick gas concrete panel at exterior wall, 10 cm thick gas concrete panel at interior wall in order to supply thermal&sound insulation and 20 cm thick gas concrete floor panel have selected due to floor span.

OSB panel covering over exterior walls and floor joists and plasterboard covering over interior walls and ceilings have applied at cold formed steel frame and timber frame systems. Load bearing exterior and interior walls are designed 15 cm thick so as to enable ease of piping, non-load bearing walls are designed 10 cm thick. Glasswool between exterior wall studs, glasswool bat over roof floor are located for thermal&sound insulation. Moreover, foamboard is covered over whole facade to prevent cold bridge. On the other hand, glass wool between interior wall stud and floor joist are applied for sound insulation.

30, 40, 50, 60 cm spacing between studs and floor joists are applied at cold formed steel and timber framing systems. Due to the fact that, dimensions of obtainable OSB on the market, 50 cm spacing is not preferred in Turkey. If 50 cm spacing is applied on a project, wastage of OSB panels increase in considerable amount. Gas concrete panels at prefabricated R.C system are manufactured as 60 cm wide. Therefore, spacing is accepted 60 cm as common convention in conformity with dimensions of components at different systems. (Figure 2, Figure 3)

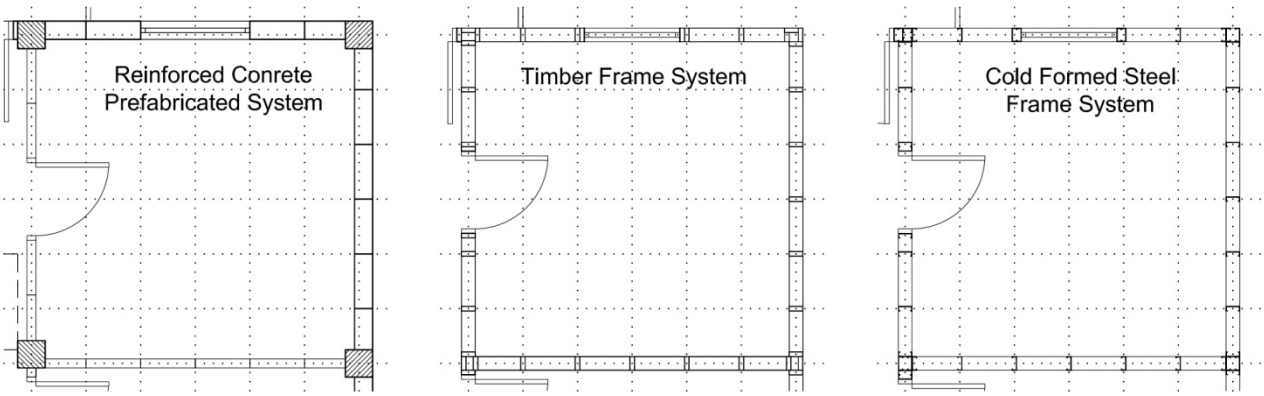


Figure 2. Layouts of vertical structural components belong to typical project

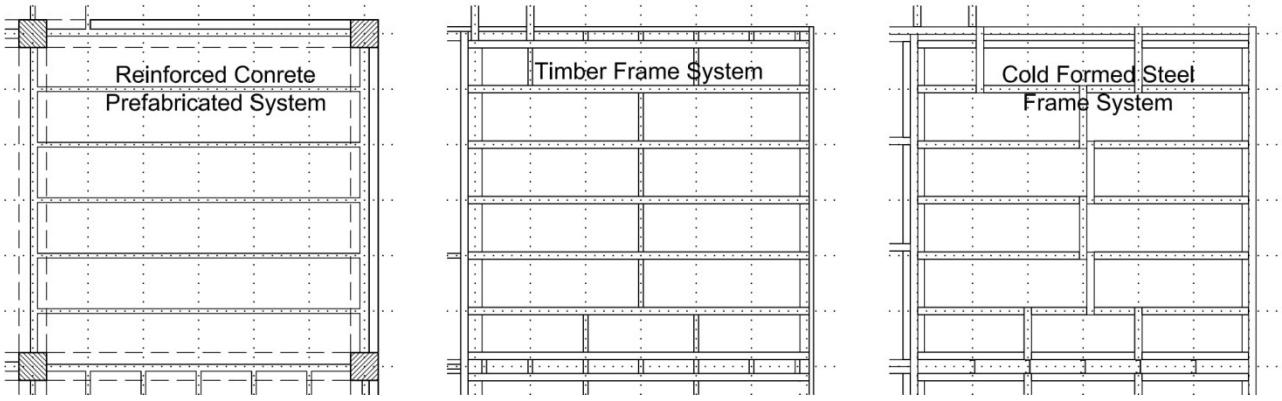


Figure 3. Layouts of horizontal structural components belong to typical project

Prefabricated R.C stick system is structurally designed according to existing standards and regulations in Turkey. Moreover, Ytong firm catalog is utilized to determine gas concrete floor panel thickness. Publications of American Wood Council (AWC) are used for timber frame structure design and got asistance from "Kınalı Ahşap Yapılar" manufacturer of timber frame structures in Turkey. Publications of North American Steel Framing Alliance (NASFA) and American Iron and Steel Institute (AISI) are used for cold formed steel framing system and got asistance from " Aksan Yapı" manufacturer of cold formed steel framing structures in Turkey.

Design and Applicability Properties

Regulations and standards related with timber frame structure in Turkey limit timber structures as two storey and deteached house (not adjoining applicable). Existing regulations and standards related with cold formed steel framing is not limiting building type and number of storey like timber structures and this makes cold formed steel framing advantageous than timber frame structures.

Timber frame standard exists in 1998 disaster regulation is repealed by 2007 earthquake regulation in Turkey. Seperate parts for timber and cold formed steel frame are not exist in 2007 earthquake regulation and mentioned as "rules for the buildings, which is out of scope of this regulation, shall be accepted related international standards, untill publish by national authorities."

Production of prefabricated R.C stick systems, which can be used in the field of low-rise residentials in Turkey, can be possible with considerable amount of component order. In cold formed steel framing system, components can be obtained from stocks as a ready product, instead of considerable amount of component order like prefabricated R.C system, by not depending on a private building, Consequently, private order is not required for cold formed steel profile in the market, and this increases the power of competitivness of cold formed steel profiles as the stock ready product.

Weight of structural system is 84,7 ton for prefabricated R.C stick system (including R.C system and gas concrete panels), 10,1 ton for timber frame system (only frame) and 6,7 ton for cold formed steel frame system (only frame). Timber frame system is 1.5 times heavy, prefabricated R.C system is 12,5 times heavy than cold formed steel frame system. Weight of structural+finishing works (finished all insulation layers and ready to painting and covering) 100,14 ton for prefabricated R.C system, 27,88 ton for timber frame system and 24,51 ton for cold formed steel frame system. Timber frame system is 1.14 times heavy, prefabricated R.C system is 4 times heavy than cold formed steel frame system.

Staircase can be constructed by without requirement of different type of component than structural component at timber and cold formed steel frame systems. Whereas, special components belong to only staircase can be used in prefabricated R.C system. Steps much more easily integrate with the structural system in terms of detail at timber and cold formed steel frame systems, even steps can be

supported by non load-bearing walls and consequently this causes design flexibility when compared with prefabricated R.C stick system.

Structural Component Properties

Small and hollow section galvanized profile used in cold formed steel framing system has higher load bearing capacity according to material weight when compared with timber frame component and not having dimension difference between wall section and columns as per in prefabricated R.C stick system.

Covered galvanize over steel plate sufficiantly protects steel against corosion during building life, therefore there is not corossion or decay risks. Not having been effected by insect, galvanized profiles do not loose load bearing capacity as happens in timber structure.

Sectional forming capability of 100% recyclable cold formed steel profile is more than sectional forming capability of timber frame‘ s component. There is variety wood kind and price for the same shape and dimension of a timber frame component. But, cold formed galvanized steel component is presented to the market with standard quality and price by manufacturers and this situation causes that cold formed galvanized steel profile is much more prefered as a constructional material.

Foamboard is covered for thermal insulation over whole facade to prevent cold bridge in order to meet interior comfort conditons and so the frame is totally isolated from atmospheric conditions. Consequently expansion or contraction due to exterior temperature has been prevented by this solution.

Production Properties

Components are produced at three phase in the factory as preparation of formwork, reinforcement and concrete pouring. Altough, reaching to full capacity strenght of concrete for usage requires specific duration, strenght of concrete can be accelerate by addmixtures so as to enable rapid production. On the other hand, components of timber frame and cold form steel frame system can be produced at one phase and with one raw material in the factory and the components are ready to be used when they are produced. Stock and transportation costs are low for light frame systems, because of small dimensions of the components.

Stocking component is not easily possible for prefabricated R.C. stick systems at construction market due to the fact that ordering material with only mass production and requirement of big stocking area. Long term stocking timber components is not also preferred by construction market because of high risk of fire and possibility of decay and termite attack.

Galvanized profiles are demanded continiuously by construction market for variety purposes and these profiles can be stocked easily without risk of fire, decay and termite attack. Cold formed profile have advantageous in terms of production among other prefabricated systems compared in this study.

Installation Properties

Cold formed steel frame platform system is a rapid construction technique in any climate conditions without requirement of mobile crane and have better sectional and connection properties with ease of piping on load bearing components than timber frame system.

Life Cycle Cost

There are very close cost values as only material prices at level of structural+finishing works (finished all insulation layers and ready to painting and covering). Final cost varies project by project and amount of mass production. Since, lifecycle cost as starting with begining of the project and covers useful period is more objective evaluation instead of evaluating only building cost. Cold formed steel framing system comes into prominance because of the reasons of 100% recycable

structural component as galvanized steel profile, low maintenance and repair costs, ease of alteration of design due to change of user preferences.

Building Used Area

The rate of net floor area to gross floor area at cold formed and timber frame systems is more than prefabricated R.C system. Should floor span increases at cold formed and timber frame systems, spacing of stud and floor joist becomes closer. Therfore, studs expand inside the wall section at timber frame system and section of galvanized profiles becomes more thick in terms of mm at cold formed steel framing system. So, the rate of net floor area to gross floor area is not effected.

COLD FORMED STEEL FRAMING SYSTEM IN TURKEY AND COMPONENT PROPERTIES

Cold formed steel framing system technology is transfered from North America by using North America‘ s specifications with establishment of firms produce cold formed steel framing after 1999 earthquake and this alternative light frame system is widespreading in Turkey. Number of factory and manufacturer of structural steel profile produced by galvanized plates with cold forming proccess is increasing in the course of time. When product range is examined, manufacturer firms produce similar products in terms of dimension and properties due to usage of same specifications.

Some firms serve only in the phase of production, some of them serve in all phases as the phases of production, design and installation in cold formed steel framing system market. Beside, some firms serve in the phase of design and installation by getting required structural cold formed steel galvanized profiles from variety main manufacturers in the condition of free market. Supplying of component is possible from the firm‘ s manufactured products which have same properties, and similar dimensions and it seems to forming of component market and developing in the course of time. Locations of cold formed galvanized steel profile factory, cold formed steel framing installation and franchisers are shown on Figure 4.

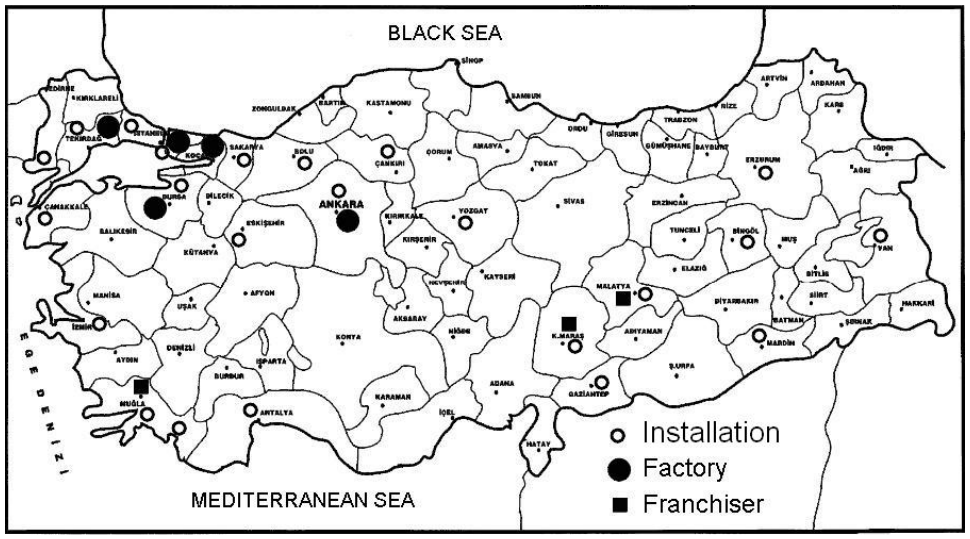


Figure 4. Locations of production, installation and franchiser of cold formed steel framing

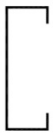
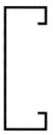
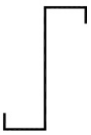
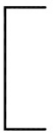
Below mentioned definition is determined after studying cold formed steel framing component’ s names and codes commonly used in Turkey with using North America’ s spesification;

- S type component: Defining as sub title of C, C+, ∑, ∑+ (named as epsilon or sigma), Z profile in manufacturer’ s catalogs

- U type component: T and U type components in North America' s specifications have same properties in tems of material and the only difference is used area. These two components are defined by one code as U profile in manufacturer catalogs in Turkey.
- F type component: Same code with North America' s specification is used in Turkey and defined "omega profile" in manufacturer catalogs in Turkey.
- L type component: Same code with North America' s specification is used in Turkey

The main component in defined components in Table 2 is S type component in terms of load bearing properties. U component depends on S component and always have to be same with S component in terms of yield strength and profile thickness. F component is used as mounting profile for ceiling and helps only to the structural system by stability of floor joist' s underside. L component is used to form lintel. Load bearing capacity of S type component used as stud and floor joist is increased by modifying it' s shape and increasing bending number.

Table 2. S and U type system components

Type of Component		S					U
		S1	S2	S3	S4	S5	
		C	C +	∑ (Sigma or epsilon)	∑ + (Sigma or epsilon plus)	Z	
Form of Component							
Used Area	Stud	X	X	X	X		Track Profile
	Beam	X	X	X	X	X	
Profile thickness		min. 1,0 mm - max. 2,5 mm					

When examined cold formed steel framing installations in Turkey, S and U type component' s steel plate thickness is applied minimum 1mm and maximum 2,5 mm. F and L type component' s steel plate thickness is applied 1mm.

S type component is named as C profile in product catalogs and installation. In order to increase load bearing capacity, bending number is increased during cold forming process, and so C+, ∑, ∑+ (named as epsilon or sigma) profile types are shaped. These type of components are not preffered in Turkish cold formed steel framing industry due to the fact that, increasing number of typical component, limited number of manufacturer, little competition in open market. Therefore S1 type component shown on Table 2 is widely used in Turkey as stud, floor joist and rafter, which are the main structural components of cold formed steel framing system.

If a prefabricated building, which is erected by the consequences of seperation of design, production and installation phases, uses common conventions accepted by the contruction industry, this shows that the potential of having open building concept. The difficult phase is organizing production phase after constituting of conventions in open building concept. Turkish cold formed steel frame industry also seems as orginized this by variety manufacturers use same specifications as North America' s specifications. Consequently, cold formed steel frame technology in the field of low rise residentials in Turkey, is able to achive design, production and installation phases as the concept of open building with using common conventions.

CONCLUSION

Demand to low rise residentials is still continuing at significiant rate in Turkey and cold formed steel frame system is able to meet existing preferences of low rise residentials. Cold formed steel frame system comes into prominence due to the technological properties and meeting existing national regulations, when low rise industrialized systems are compared in terms of design, production and installation.

Producer' s of galvanized profiles for cold form steel framing produce similar components as quality and dimensions in Turkey with using North American' s codes and specifications during production phase which is the difficult phase as organizational among the phases of design, production and installation. Therefore, there is potential of consisting of component market in Turkey. In this respect, component types of cold formed steel framing system which can be used in Turkey are defined in this study.

A national cold formed steel framing system can be designed as the concept of open building with limited component by using a common convention shown on a system catalog. Manufacturer firms ,who have the activity in cold formed steel framing industry in Turkey, and designers can seperately contribute to designed system.

REFERENCES

AISI, (2001), Standard for Cold-Formed Steel Framing – General Provisions, AISI/COFS/GP 2001, American Iron and Steel Institute, Washington

Avlar, E., (2008), Determination Through Timber Frame Production in Turkey, Material in Architecture, issue 2008/2, pg; 71-76, *TMMOB Chamber of Architects*, Istanbul

Ayaydın Y., Koman, İ., (2004), Concrete Prefabrication in 12 Question, *Building Information Centre*, Istanbul

ABYYHY, (1998), Specifications for Structures to be Built in Disaster Areas, *The Ministary of Public Works and Settlement,* Ankara

DBYBHY, (2007), Specifications for Structures to be Built in Earthquake Areas, *The Ministary of Public Works and Settlement,* Ankara

CSSBI, (2005), The lightweight steel frame house construction handbook, *Canadian Sheet Steel Building Institute (CSSBI)*, Canada

TUIK, (2000), Result of 2000 Building Statistical, *Turkish Statistical Institute,* Ankara

IBB, (2007), Regulation of Istanbul Development Plan, *Istanbul Metropolitan Municipality,* Istanbul

Larson, J, W., (2007), AISI Standards for Cold-Formed Steel Framing, Construction Standards Development, American Iron and Steel Institute, Washington

NASFA, 2000. Prescriptive Method for Residential Cold Formed Steel Framing, *North American Steel Framing Alliance (NASFA),* Chicago

STAHL, (2002), Wohnungsbau mit Stahl - Profilhandbuch, *Stahl Informations Zentrum*, Document Referance No: Markblatt 480, Dusseldorf

TPB, (2006), Report of 2006 Precast Concrete Sector, *Turkish Precast Concrete Association*, Ankara

TS 498, (1997), Design Loads for Buildings, *Turkish Standards Institution*, Ankara

TS 825, (2008), Thermal Insulation Requirements for Buildings, *Turkish Standards Institution*, Ankara

TUIK, (2006), 2006 Turkish Statistical Yearbook, *Turkish Statistical Institute,* Ankara

YEM, (2007), Report of 2007 Turkish Building Sector, *The Building Information Centre*, Istanbul

Yıldırım, S.G., (2010), The Proposal of Semi-Open Cold Formed Steel Framing System For Low Rise Residentials in Turkey, *Ph.D. Thesis, Istanbul Technical University, Institute of Science and Technology*, Istanbul

YTONG, (2008), Reinforced building components catalogue, *www.ytong.com.tr*