COLD FORMED STEEL FRAMING SYSTEM IN TURKEY
Industrial Development

Asst. Prof. Dr. Semih Göksel Yıldırım[a]

[a] Istanbul Arel University, Dept. of Architecture, Turkey

INTRODUCTION

After 1999 Izmit Earthquake, alternative low rise residential construction systems came into agenda in construction industry and in relation to this cold formed steel framing (CFS) system was presented to media as "earthquake resistant building". 2001 financial crisis in Turkey postponed acceptance of newly introduced systems or materials in construction industry. Construction industry was recovered by inclining trend of economy between 2004 and 2008. Thus, CFS system occupied reasonable rate in construction industry during this period. Number of firms serve in variety levels of design, production and installation phases are increasing particularly in metropolitan cities such as Istanbul and Ankara. Thus the aim of this study is; determination of existing situation of CFS system in Turkey and prepare a foresight through future. This study comprises the evaluation of component supply, used standards, building cost in terms of development of CFS system in Turkey, instead of research on design, production and installation properties.

1 PRODUCTION OF COLD FORMED STEEL FRAME HOUSING

Approximately 600.000 unit residential production including renovation is required annually in Turkey due to existing speed of population growth, therefore residential construction market is still active. 85 percentage (13,800,455 residential) of existing building stock is low rise buildings with one to three storey. 566.674 residentials were constructed in 2006 and among these residentals; 38,7 percentage (219,302 residential) has one and two storey and 43 percentage (243,669 residential) has three to five storey. Consequently approximately 300.000 residentials with one to three storey are being constructed annually.

On going low rise residential projects in Istanbul have been studied according to structural type in 2008, relating to how many residentials were constructed by CFS system to meet existing housing demand. Istanbul has been chosen for this study because of having high risk of earthquake and high density of population. The chosen projects belong to middle or upper class. 13,425 residential has been examined and 4 percentage (526 residential) of this total examined projects is constructed by CFS system. Because of not to be built in other parts of Turkey as much as in Istanbul, the rate of this 4 percentage for CFS system can not to be applied to other part of Turkey.

CFS system is more costly than other low rise construction systems in Turkey because of limited firm number and not well-known in the level of technical staff. But the initial target for becoming widespread of CFS system in Turkey shall be; implementation of the rate of this 4 percentage to all part of Turkey. Not only targeting to meet the demands of middle or upper class, CFS system shall be affordable by all levels of community in Turkey as happens in other low rise residential construction systems. Furnishing this kind of widespread of CFS system is possible by supplying price competition.

Average residential area is 148 m2 in Turkey and 4 percentage of resendentials as 1 to 3 storey is 12,000. Total construction area of residentials which can be built by CFS system is aproximately 1,776,000 m2 annualy so initial target volume of CFS system market in Turkey is almost 700 million US dollars. In order to get share from this market, several firms are founded and these firms are categorized under three headings;

Category I Firm: completed system development, presenting its system in firm catalog, producing system components as galvanized profiles and marketing these profiles to Category III firms.

Category II Firm: only producing system components as galvanized profiles, supplying stock ready components to the market.
Category III Firm: serve only during phases of design and installation by furnishing required system components from producers in the condition of free market. This kind of firm number is increasing in the course of time in relation to the size of CFS system market.
Nevertheless, some franchisee from different regions serve during phases of installation by getting technical support and material supply from category I and II firms. But only the firms included in category I and II are examined in this study as the main player in the market and their capasities are shown in *Table 1*.

Table 1. CFS system producers and capacities

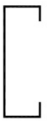
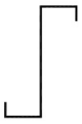
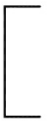
	Name of Firm	Category	Production Capacity (m2 / year)	City Located	Website
1	Akşan	I	600.000	İstanbul	http://www.aksanworks.com
2	Vefa Group	I	240.000	İstanbul	http://www.vefagroup.com
3	Proev	I	500.000	İstanbul	http://www.proev.com
4	Apec Çelik	I	640.000	İstanbul	http://www.apec.com.tr
5	Park Profil	II	320.000	İzmit	http://parkpanel.com.tr
6	Badeçelik	I	200.000	Ankara	http://www.badecelik.com.tr
7	Sarp Villa	I	150.000	Ankara	http://www.sarpvilla.com.tr
Total Capacity			2.650.000 m2/year		

These firms are able to produce galvanized profiles for totally 2.650.000 m2/year of CFS system. Therefore production capacity meets existing CFS system demand in the market. On the other hand franchising network is developing inside Turkey and construction activities relating with CFS system is increasing abroad.

1.1 Produced component types

Production of constructional steel bar as "long product" is above the demand of Turkish construction market. The production rate of "flat products" is 13 percentage and "long products" is 85 percentage in total steel production of Turkey. New investments are on going in order to increase the production rate of "flat products". Deficiency in production of "flat products" is being met by import. Consequently, furnishing cold rolled galvanized products used for production of CFS system component is possible without any obstacle.

Table 2. Component types

Type of Component		S					U
		S1	S2	S3	S4	S5	
		C	C +	Σ (Sigma or epsilon)	Σ + (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					

Galvanized steel profile producers produce similar components by using same international specifications as North American specifications. Typical components produced and used in Turkish

CFS system market are shown in *Table 2*. Minimum steel plate thickness for CFS system components is defined as 0,84 mm in North American specifications and 1,0 mm in Eurocode 3. Steel plate thickness is defined in the product catalogs between 1 mm and 2,5 mm as widely used in CFS system construction in Turkey. Therefore, production and usage of galvanized steel profiles for CFS system construction is in conformity with international standards.

1.2 Used design criteria

Lack of prescriptive method regarding with CFS system apart from specifications and standards effects general acceptance of this system by designer and public authorities. In order to meet this requirement, decrease legal limitations, increase reliability and make it affordable, prescriptive methods has been published in North America. Similar publications shall be published in Turkish language too. Separated specifications and standards were published for either load calculations and structural design. But the hierarchy of these documents which will be used during design phase is determined in *Fig. 1*.

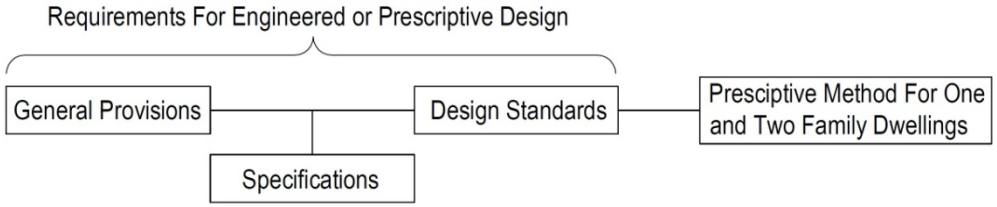


Fig. 1. Document hierarchy

Building proportion, number of storey and used design standards during design phase are shown in *Table 3* in order to monitor existing situation of CFS system design criteria in Turkey.

Table 3. CFS system design criteria

Building Proportion Acc. To Regulations	Max. Number of Storey Acc. To Technological Limitations and Regulations	Local Standards	International Standards
Detached or Adjacent	3	TS-11372, ABYBHY-2007, TS 498, TS 914 EN ISO 1461, TS EN 10327	AISI and NASFA standards, Eurocode 3 1993 1-3

Limitation is not existing in terms of building proportion and number of storey. But for instance; timber frame system can not be designed as detached house and more than 2 storey in Turkey because of regulations. Seperated division do not exist for CFS systems in Turkish earthquake specification published in 2007, but it is mentioned in item 1.1.7; “international specifications shall be used for designing of the buildings of which is out of scope of this regulation until publishing related own local regulations” and “any building shall supply general conditions mentioned in second division”.

Galvanized steel profile producers in Turkey use North American standards in addition to local standards. Because of usage of similar standards, similar components are being produced. But usage of international publications during design and approval procces is limited at national level because of publication language.

2 LIFE CYCLE COST OF COLD FORMED STEEL FRAMING

A study has been conducted for building cost of CFS system in the condition of Turkey. Evaluation of life cycle cost (LCC) of a building is more appropriate instead of evaluating as only construction cost. LCC for a building covers several periods as; definition of building requirements, preparation of feasibility, design, construction, operation, maintenance, change due to user requirements and demolishment. LCC evaluation is narrowed in this study only through structural system for

objective comparison and selection of structural system. Henceforth LCC of a building covers in this study design, construction and utilization periods.

2.1 Used evaluation method

Method of "*evaluation with different importance ratio of asset criteria and sub-purpose*" is applied in this study. First, importance ratios of sub-purposes (G) that depends on a evaluation system are determined. Secondly, sub-purposes are analysed according to fulfilling of these sub-purpose, than sub-purpose value (B/b) is decided. Finally, utility value (fd) is calculated according to importance ratio of each item. A measurement scale is chosen according to properties of each asset criteria or sub-purpose. Values from the worst to the best are determined in *Table 4*.

Table 4. Numerical measurement scale (B/b)

1	2	3	4	5
very bad	bad	sufficient	good	very good

2.2 LCC evaluation

Cold formed steel framing system, timber frame system and prefabricated reinforced concrete system came into the Turkish construction agenda as alternatives to conventional reinforced concrete system after 1999 Izmit earthquake. Even though CFS system has advantage in terms of properties of design-production-installation during period of selection of structural system, evaluation of LCC aspect is being evaluated and presented at *Table 5*.

Table 5. Cost comparison of alternative structural systems

STRUCTURAL SYSTEM COST			SYSTEM 1 PREFABR. R.C. SYSTEM	SYSTEM 2 TIMBER FRAME SYSTEM	SYSTEM 3 CFS SYSTEM	SUB-PURPOSE / ASSET CRITERIAS		SYSTEM 1 PREFABR. R.C. SYSTEM		SYSTEM 2 TIMBER FRAME SYSTEM		SYSTEM 3 CFS SYSTEM	
						G	g	B/b	Fd	B/b	Fd	B/b	Fd
DESIGN COST	1	STRUCTURAL PROJECT	1,0 unit	1,1 unit % 10 costly	1,1 unit % 10 costly	1,50%	100%	3	0,05	2	0,03	2	0,03
	2	OFFICIAL APPROVALS	DUE TO AREA	DUE TO AREA	DUE TO AREA	0,50%	100%	3	0,02	3	0,02	3	0,02
CONSTRUCTION COST	3	CONSTRUCTION (Structr + Covering) (Firm prices)	225-322 (USD/m2)	290-451 (USD/m2)	258-483 (USD/m2)	50%	100%	3	1,50	3	1,50	3	1,50
		ONLY CONSTR. MATERİAL (Structural + Covering)	107 (USD/m2)	108 (USD/m2)	114 (USD/m2)								
	4	PRECAUTIONS AGAINST FIRE RESISTANCE	LESS	MORE	MORE	3%	100%	5	0,15	2	0,06	2	0,06
UTILIZATION COST	5	RECYCLING OF STRUCTURAL COMPONENTS	NOT POSSILE	POSSIBLE (loss happens)	POSSIBLE (%100)	15%	100%	0	0,00	2	0,30	5	0,75
	6	MAINTENANCE	MORE	LESS	LESS	15%	100%	2	0,30	3	0,45	5	0,75
	7	ALTERATION DUE TO USER REQUIREMENTS	NOT EASY	POSSSIBLE	POSSSIBLE	15%	100%	1	0,15	3	0,45	4	0,60
TOTAL						100%			2,16		2,81		3,71
RANKING									3		2		1

The basic property of prefabrication is being rapid in construction, hence this property shall to be a cost reduced factor. CFS system as a still new alternative construction system for Turkish construction industry shall also capable to compete with its price in the market. Cost comparison through LCC cost has been done for design cost, construction cost and utilization cost. Cost results in *Table 5* belong to the year of 2009, because of conducting the study in mentioned year.

Precautions against termite attack and decay shall to be taken into consideration for timber frame system during maintenance period and material loss happens during dismantling of structural wooden components.
Comparison made in the level of structural and covering in order to supply same building comfort conditions in terms of sound and thermal insulations so objective comparison is aimed between prefabricated systems.
"Structural and covering construction" is defined as; installation of internal and external walls, insulation materials, electrical cables, mechanical pipes, leaving internal walls and ceilings ready to paint, leaving floor, roof and external walls ready to final finishing.
It is not posssible to say that a specified system is adventageous than the other one by looking to construction cost. That differs from project by project and amount of mass production. The price offered by firms for R.C. prefabricated system is valid by only attaining sufficient amount of mass production. But it is not required for CFS and timber frame systems to attain a specific amount of mass production, even the prices shown are valid for single houses. Accordingly, construction cost item shall be evaluated from this point of view.
Having limited number of competing firms, little market volume and awareness at the level of technical staff by evaluating existing situation, price offers for CFS system by the firms is above than other alternative construction systems in the condition of free market. Whereas, costs are so close in terms of only constructional material. This shows that CFS system is not expensive when compared for only material cost.

3 CONCLUSION

After analysing firm structures, component types, production capacity, used standards and building cost, a proposal through future for industrial development of CFS system in Turkey is being presented in conclusion.
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 this respect, the industrial trend of CFS system seems to be in a state of transition through "open building" concept in the field of low rise residential in Turkey. The initial target as 4 percentage of housing (one to three storey) construction market in Turkey by CFS system shall to be attained that the CFS system industry is able to step forward. In order to become widespread of this system throughout whole Turkey below mentioned items are being proposed;

- targeting transition to open building concept by existing firms
- publication of prescriptive method in Turkish language
- awareness in the levels of public authorities and technical staff shall be increased
- providing public support (such as; realization of permanent disaster house in the speed of temporary disaster house, construction of some low rise public buildings by CFS system)
- periodic registration of CFS system production in Turkey under a roof of steel institution or association

Finally, 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 catalogue. Manufacturer firms, who have the activity in cold formed steel framing industry in Turkey, and designers can separately contribute to designed system.

REFERENCES

[1] SBBSZ, *Specifications for buildings to be built in seismic zones (2007)*, The Ministary of Public Works and Settlement, Ankara, 2008.
[2] MPWS, *Yapı yaklaşık birim maliyetleri 2001-2007,* The Ministary of Public Works and Settlement, Ankara, 2008.

[3] TISPA, *2008 Faaliyet raporu*, Turkish Iron and Steel Producers Association, retrieved from http://dcud.org.tr, August 28, 2008.
[4] Ekinci, S., Eşsiz, Ö., "Deprem bölgelerinde hafif çelik yapım sistemleriyle üretilen konutların uygulanabilirliği", *Earthquake Symposium*, Kocaeli, March 23-25, 2005.
[5] HUT, *Residential open building*, Helsinki University of Technology, retrieved from http:// hut.fi, March 21, 2005.
[6] IMM, *2007 Istanbul imar planı*, Istanbul Metropolitan Municipality, Istanbul, 2007.
[7] Larson, J, W., *AISI Standards for Cold-Formed Steel Framing*, Construction Standards Development, American Iron and Steel Institute, Washington, 2007.
[8] Milliyet Emlak, *İstanbul konut sektörü raporu*, Emlak Dünyası, retrieved from http://milliyetemlak.com, May 19, 2007.
[9] NASFA, *Prescriptive Method for Residential Cold Formed Steel Framing*, North American Steel Framing Alliance (NASFA), Chicago, 2000.
[10] Okan, A, *Bina tasarımında performans yaklaşımı ile maliyet denetimi*, Ph.D. Thesis, Istanbul Technical University, Faculty of Architecture, İstanbul, 1975.
[11] STAHL, *Wohnungsbau mit Stahl - Profilhandbuch*, Stahl Informations Zentrum, Document Referance No: Markblatt 480, Dusseldorf, 2002,
[12] Şenkaya, E., *Türk konut sektörünün bugünkü durumu ve yeni konut tipi trendleri*, retrieved from http://yapiworld.com, September 17, 2005.
[13] Tapan, M., *Mimarlıkta değerlendirme*, Istanbul Technical University publication, İstanbul, 2004.
[14] Terim, B., **"**Hafif çelik çerçeve sistem", Ege Mimarlık, Vol. 1, pp. 56, İzmir, 2006.
[15] TPCA, *Sectorel report in 2006*, Turkish Precast Concrete Association, Ankara, 2007.
[16] TSI, *2000 yılı bina sayım sonuçları*, Turkish Statistical Institute, Ankara, 2001.
[17] TSI, *Türkiye istatistik yıllığı 2006*, Turkish Statistical Institute, Ankara, 2007.
[18] YEM, *Türk yapı sektörü raporu 2007*, The Building Information Centre, Istanbul, 2008.
[19] Yıldırım, S.G., *Türkiye' de az katlı konutlar için yarı açık hafif çelik yapım sistemi önerisi*, Ph.D. Thesis, Istanbul Technical University, Istanbul, 2010.
[20] YTONG, *Donatılı yapı elemanları kataloğu*, retrieved from www.ytong.com.tr, November 19, 2008.