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Technical and economic assessment of building performance through light metal frame (LSF)

Hamid Mehdizadeh[1*], Mehdi Ravanshadniya[2]

[1]*M.Sc. in Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran, Iran*
[2]*Assistant Professor in Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran, Iran*

Abstract

Using LSF in recent years has been remarkable in many countries of the world due to many advantages, including speed and high quality construction and good seismic performance, the need to high quality construction, durability and useful life of buildings, improving the seismic performance buildings under construction, and attempting to resolve lack of housing or other spaces and buildings in most countries explain the necessity of using new technologies and new production methods rather than traditional systems and inefficient buildings. In order to determine the differences between LSF system and traditional systems prevalent in the country in the construction of low-rise buildings, several different projects using structural systems of ordinary steel, concrete structures and LSF system design and the results obtained were compared. Projects include three buildings with two, three, and five floors that are designed using all three methods and relatively comprehensive comparison of results is presented. The results show that using LSF has seismic appropriate performance due to its ability for reducing the relative location, reducing structural weight by approximately 40% greater than the metal currency, reducing the consumption of concrete by about 60% compared to concrete structures common and 30% greater than the metal current performance. By examining the numerical differences between the design criteria LSF systems and traditional systems of construction of the country, LSF system is very convenient and safe to make effective use of its advantages that localization and training systems in decision-making of different sectors including Building and Housing Research Center is recommended.

Keywords: technical and economic assessment, Light metal frames, LSF

Introduction

The construction industry in the country in recent decades has faced many problems in terms of quality and quantity. In terms of quality, most stable and reliable construction of buildings is not resistant against weather conditions and natural disasters (earthquake and wind) and construction also created the most problems for the environment due to their implementation.

The current deficiencies in terms of a lack of accountability in the construction sector and building production to new requirements including high population growth, the need to rebuild buildings destroyed by natural effects, need to change the ways of construction due to rising living standards and changing needs of people's lives can be pointed out. Inappropriate methods of implementation include doing more operations, building on the construction site and its reliance on the use of a large number of construction workers.

As the workers have to do hard work in site, these kinds of jobs are considered as hard jobs. Therefore, in our society often technical people in the field do not have passion to work because they are often unskilled workers in this sector. It may easily be the main factor in creating quality problems in the construction sector due to lack of skilled workers in the construction site in technical offices and consulting engineers usually advanced software and information days for calculation and design of the building as well as its high level of safety factors in the design and planning would arise problems for the building. (Fallah and Oskouei, 2002)

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Experiments have shown for use in industrial production practices, further above problems can be solved. Studies have shown a direct correlation with the duration of the construction cost of the building. Therefore, the use of technology in the construction sector can partly solve the above problems.
LSF system of cold rolled steel sections built CFS in recent years largely in manufacturing all kinds of office buildings, commercial and residential been used. The method in developed countries as a viable alternative to traditional methods of manufacture, presentation and its widespread use began. For an analogy between the structures in question, similar conditions such as location, similar wind conditions, conditions similar structure, and a similar plan is evaluated. The results show that using LSF has seismic appropriate performance due to its ability for reducing the relative location, reducing structural weight by approximately 40% greater than the metal currency, reducing the consumption of concrete by about 60% compared to concrete structures common and 30% greater than the metal current performance. By examining the numerical differences between the design criteria LSF systems and traditional systems of construction of the country, LSF system is very convenient and safe to make effective use of its advantages that localization and training systems in decision-making of different sectors including Building and Housing Research Center is recommended. Building industry in the country in recent decades has faced many problems in terms of quality and quantity. In terms of quality, most stable and reliable construction of buildings are not resistant against weather conditions and natural disasters (earthquake and wind) and construction also created the most problems for the environment due to their implementation. (Gourtani et al., 2009).
Since there are a few studies in Iran on this issue and building system compared to conventional systems and given the increasing use of these systems in industrial construction, in particular the need for further research to evaluate the technical and economic system and its comparison with traditional systems is inevitable.

Cold Formed Structures

Generally, structural steel buildings are two major family members. A group of them familiar batch hot rolled sections that is very common. The other cold rolled sections (Cold Formed) are of sheet, strip or belt of cold rolled steel with and without the use of heat are produced.
In this type of components, forming the steel sheet is carried out by mechanical methods without preheating sheets (cold rolled). According to the specs sheet leaves cold treatment effect in this case, the plastic strain, strain hardening and Bauschinger effect alters the properties of the sheet resistance. The investigations carried out in respect of cold rolled sections can be seen, degree heat produced by the behavior of different stability compared to the base plate (Bagheri, 2012).
As a result of heat treatment, respectively, an increase of flow resistance, reducing the ultimate tensile strength and ductility is reduced. The greatest impact in a cold rolled sections at the corners and curves it can be seen. Production method and type of operations, changes in rates of rolling work of these sections is very effective, depending on what method is chosen for the production of cold rolled parts, different behavioral changes. Working with the rollers rolling method with regard to pressing parts creates more resistance. The increase in yield strength and resistance changes, especially in the more important in the calculation sections that should be considered.
The method includes applying pressure forming operations on steel sections and rolled by machines, rollers and presses for the production of sections with various forms. The thickness of the sheet or cold-rolled steel strips to produce sections between 0.40 mm to 25 mm. Of course, the desired thickness ranges between 0.60 mm to 2.50 LSF for structural system mm.
Using cold-rolled sheets and sections prepared by the method of construction since 1850 in the United States and the United Kingdom, but the expansion of these sections used in the construction industry since the 1940s, and after the first release versions of AISI rules and standards for cold rolled steel structural members accelerated and a basis for the development of cold-rolled systems such as LSF (Mostajeran et al., 2009).

Design of several projects using different methods

In order to determine the differences between LSF system with traditional systems prevalent in the country in building a short-order and the order, in the number of projects using structural systems of ordinary steel, concrete and LSF system design and results has been compared to one another. Enterprises including two, three, and five buildings by using all three methods designed to compare the relatively comprehensive results. Table 3-1 details can be seen in projects designed (Vosuqifar et al., 2009)

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Characteristics of projects

Roof Systems	Lateral force resisting system		Structural system		Construction System	Number of classes
	Y	X	Y	X		
Block Joist	bracing frame	Intermediate bending frame	steel	Bending frame	Steel	2
Block Joist	Intermediate bending frame		Bending frame		Concrete	
composite	Tensile bracing system		Simple frame		LSF	
Block Joist	bracing frame	Intermediate bending frame	steel	Bending frame	Steel	3
Block Joist	Intermediate bending frame		Bending frame		Concrete	
composite	Tensile bracing system		Simple frame		LSF	
Block Joist	bracing frame	Intermediate bending frame	steel	Bending frame	Steel	5
Block Joist	Intermediate dual system		Bending frame		Concrete	
composite	Intermediate shear wall		Simple frame		LSF	

The design of two-floor building systems using steel, concrete and LSF
Use of LSF is common in many countries in construction of buildings 1 and 2 floor residential buildings, villas, offices, small businesses, educational and industrial units due to advantages such as light weight, economical, low consumption building materials, increasing the useful space inside, audio performance high and low energy waste. In this two-floor residential building with a floor area of 100 square meters on each floor, using the above methods is designed in the form of software-dimensional images of the models offered in each system (Vosouqifar et al, 2009).

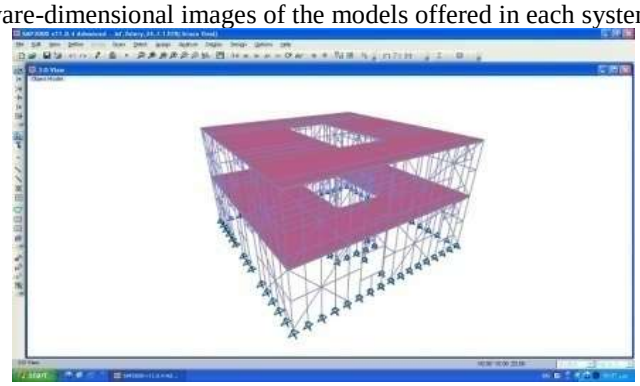

Figure 1: Project designed with LSF system software using SAP2000



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Figure 2: Project designed with conventional steel structural system using the software ETABS

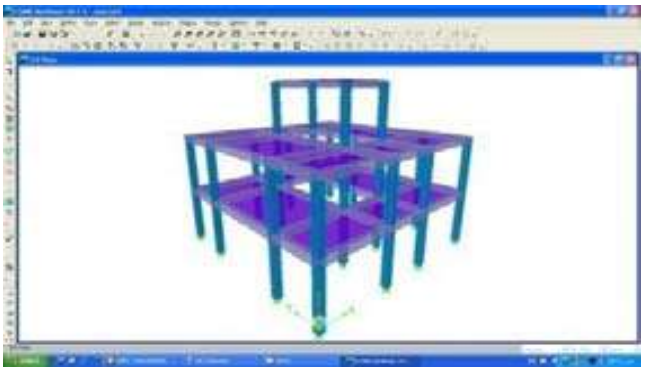

Figure 3: Project designed with reinforced concrete structural system using the software ETABS

The results obtained for this project is presented in Table 1. It should be noted that in calculating the amounts set forth in Table 1, materials used in building the foundation are also considered. As can be seen using LSF system leads to significant reductions in weight, the force of the earthquake, materials and time spent for building is (Vosuqifar et al, 2009).

Table 1: Comparison of LSF system features and concrete building in two-floor building

Concrete structural system	Ordinary steel structural system		LSF system	Important parameters
	Direction Y	Direction Y		
33.25	55		25.12	The amount of reinforcing steel and Consumption (kg / m ^ 2)
1140.4	546.5		240.4	The amount of concrete used (kg / m ^ 2)
112.25	10.25		4.53	Building structure weight (ton)
317.6	209.18		86.4	The total weight of the building (ton)
36.2	26	24	16.1	Cut the base of the building in an earthquake (ton)
1.78	0.26	1.67	0.78	Most shift the center of gravity of the roof (cm)
75	60		25	The time taken for the hard work (day)
120	120		35	The time taken for joinery (day)
150	100		2	Perth materials (kg / m ^ 2)

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The design of three-floor building using steel, concrete and LSF systems



Figure 4: Project design with LSF system software using SAP2000



Figure 5: Project design with conventional steel structural system using the software ETABS



Figure 6: Project design with reinforced concrete structural system using the software ETABS

Selecting different ways to implement the project leads to different results is that most of these results is presented in Table 2. As can be seen in the construction utilizing a short-order LSF system leads to significant savings in time and materials. Due to the very low loss materials used in addition to the national capital consistent with preserving the environment will be very effective (Vosuqifar et al, 2009).

Table 2: Comparison of LSF system features and concrete building in three-floor building

Concrete structural system	Ordinary steel structural system		LSF system	Important parameters
	Direction Y	Direction X		
33.25	60.25		25.74	The amount of reinforcing steel and Consumption (kg / m ^ 2)

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1170	521.4		240.4	The amount of concrete used (kg / m ^ 2)
173.4	16.3		6.96	Building structure weight (ton)
478.25	303.6		117.28	The total weight of the building (ton)
55.6	39.3	33.8	24.3	Cut the base of the building in an earthquake (ton)
3.3	0.57	3.18	2.33	Most shift the center of gravity of the roof (cm)
120	90		35	The time taken for the hard work (day)
150	150		45	The time taken for joinery (day)
150	100		2	Perth materials (kg / m ^ 2)

The results presented in Table 2 show the weight of the skeleton structure of the LSF structural steel is about 40% and about 95% lighter than concrete structures. In addition to reducing the seismic forces that cause the preparation and installation of LSF system components easily and without the use of special equipment possible. In comparison with conventional steel construction using LSF system required the use of steel and concrete were reduced by about 50 to 55% (Vosuqifar et al, 2009).

According to the results in Tables 1 and 2, LSF system due to exposure to seismic forces much less than other systems is a good seismic performance. Based on the results of the three-story design LSF, maximum lateral displacement relative to the roof level equal to 15 mm is measured

According to the recent studies, the behavior of shear wall panels LSF in fewer locations ranges from 18 to 20 mm for linear. Thus, in the not-so-strong earthquakes used in skeleton members LSF system except braces remain in the linear region and it will continue to work after the earthquake with minor repairs (Moqimi and Ronaq, 2008).

The design of five-floor building using steel, concrete and LSF

Since mid-rise buildings will include a significant portion of the country's construction, In order to clarify the advantages of the system LSF times in the construction of this project is related to the implementation of a 5-storey residential building in an area with high seismic hazard, using three methods designed according to the model of the software in any way can be seen in Fig.

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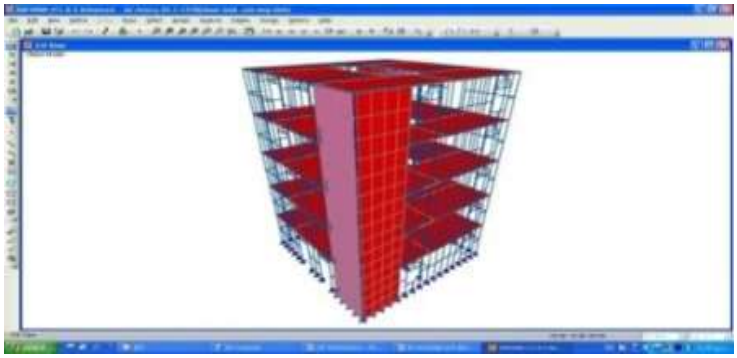

Figure 7: Project design with LSF system with software SAP2000

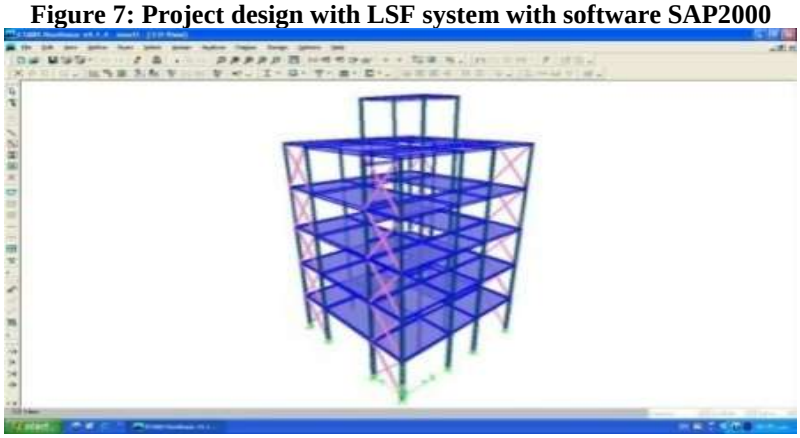

Figure 8: Project of design with conventional steel structural system with software ETABS

LSF to provide stability against lateral forces of concrete shear wall system is used. Table 3 Comparison of LSF system with steel and concrete systems is provided. As can be seen using LSF system instead of concrete and steel building seismic forces were 40% and 30% (Vosuqifar et al, 2009).



Figure 9: Project of design with reinforced concrete structural system with software ETABS

Table 3: Comparison of LSF system features and concrete building in five-floor building

Concrete structural system	Ordinary steel structural system		LSF system	Important parameters
	Direction Y	Direction Y		
45	72.4		35	The amount of reinforcing steel and Consumption (kg / m ^ 2)
1309.8	519		254.2	The amount of concrete used (kg / m ^ 2)
311.4	31.6		9.7	Building structure weight (ton)

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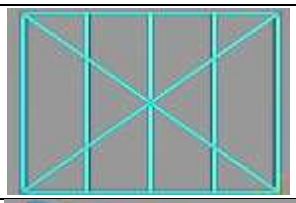
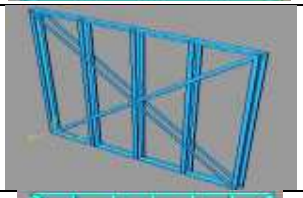
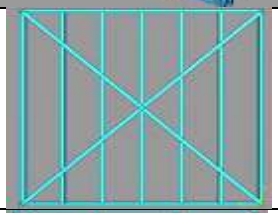
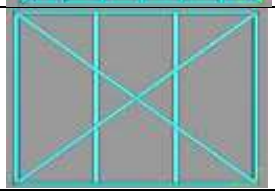
822.2	509.9		278.3	The total weight of the building (ton)
79.2	69.6	59.8	45.9	Cut the base of the building in an earthquake (ton)
1.11	2.6	4.6	0.45	Most shift the center of gravity of the roof (cm)
180	150		60	The time taken for the hard work (day)
180	180		90	The time taken for joinery (day)
200	150		5	Perth materials (kg / m ^ 2)

According to the comparison made in the preceding sections indicate that LSF system compared to systems using steel structure and concrete structure will lead to a significant reduction in materials consumption. In figure, the amount of materials used in the different systems is compared with each other for three-floor building.
The results show that using LSF has seismic appropriate performance due to its ability for reducing the relative location, reducing structural weight by approximately 40% greater than the metal currency, reducing the consumption of concrete by about 60% compared to concrete structures common and 30% greater than the metal current performance. By examining the differences numerical design criteria between systems LSF and popular system for building the country, confirms this point is to make the effective use of its advantages, the system LSF feature is very convenient, yet safe, which is the correct use along with its localization and training systems decision-making in different sectors including building and housing Research center is recommended (Vosouqifar et al, 2009).
Analysis of LSF system shear wall panels with software ABAQUS Characteristics samples of shear walls, which have been investigated under lateral load can be seen in Table 4.

Table 4: Characteristics of samples analyzed

Characteristics of Sample	Characteristics of Sample	Image of sample	No.
–	Distance between columns 60 cm X braces on one side The thickness is multiplied in sample 1-B		1-A 1-B
Adding bracing to the front side	Distance between columns 60 cm X braces on two sides		2
Reducing the distance between columns	Distance between columns 40 cm X braces on one side		3
Increasing the distance between columns	Distance between columns 80 cm X braces on one side		4

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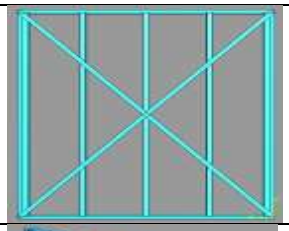
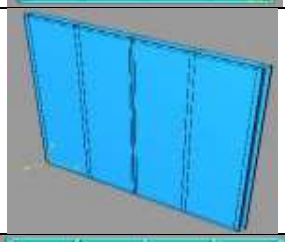
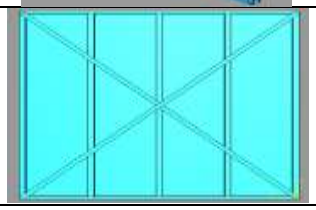
Use of double column in two sides of sample	Distance between columns 60 cm X braces on one side Double columns used in the end of samples		5
Increasing the thickness of coating	Distance between columns 60 cm X braces on one side The thickness of coatings increased in samples 6-B and 6-C		6-A 6-B 6-C
Adding concrete coating to the front side of sample 1-A	Distance between columns 60 cm X braces on one side and the concrete coating in other side		7

Comparison of 1-A and sample 1-B

As seen in Figure 10. The diagram of forces - SHIFT sample 1-A shows the behavior of deformation under load side. In this form of displacement in millimeters, and the shear strength is expressed in terms of tone. Delivery of the relative displacement ratio of 0.6% occurs due to the occurrence of the strain - Difficulty in braces, after the delivery of the cargo will continue. By increasing the thickness of one millimeter to two millimeters, column of lateral stiffness and strength of panels increase to 10%. This is shown in the figure below (Gourtani and Saadatpour, 2009).

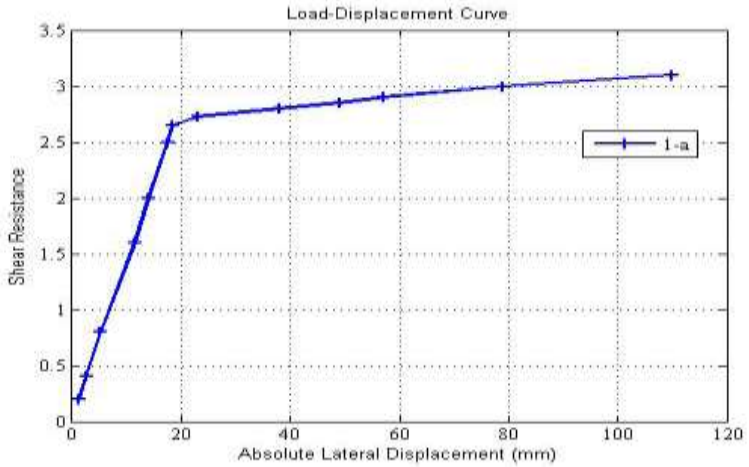


Figure 10: The load-displacement examples 1.A.

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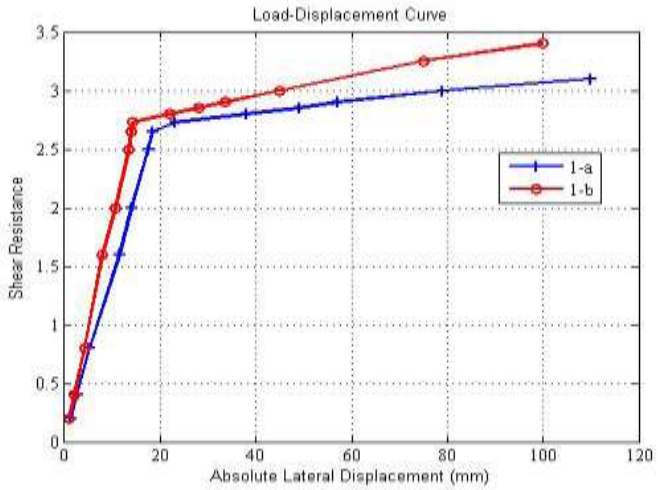

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Figure 11: Comparison Sample 1-A and sample 1-B

According to the material presented in the preceding sections obtained the following results:
1) Use of brace system in tensile and shear walls LSF due to capacity loads in the braces after the delivery side of the wall panels will lead to ductile behavior. For ductile behavior, submitting a wall braces must occur, so bracing connections should be braced to the end wall and upper and lower runner with resistance more that bracing resistance. Since the maximum amount of lateral displacement of 7.8 mm was measured building and submitting all samples occurs in about 18 mm lateral displacement; it was concluded during an earthquake LSF system remains linear medium range.
2) The use of cross bracing on both sides of the wall increases the strength of the wall. In addition, the use of bracing on both sides due to the symmetrical distribution of the load on the column and prevent the occurrence of which will twist or distortion. Of course, the use of braces on the inner side of the operation panel thin wall work a little difficult. This issue when using square plate to connect braces will be more sensitive.
3) Use of double panels will increase the load capacity. Since the loads acting on the column and the vertical component of the force is added to the brace force, the use of double column panels will increase the load capacity. Because connection plate usually cannot be used in brace, the central problem in connecting bracing members of space Fences perfect makeup automatic screw that the problem will be resolved by additional columns.
4) Application of non-structural strength and stiffness of shear wall panels significantly increase. Non-structural coatings with various types such as plaster, cement, wood and steel with the inner workings of your page load increase Accessories and raise energy absorption capacity; although brittle behavior of materials used in the construction of the wall panels is reduced ductility. Use a large number of automatic screw in connection to the skeleton wall coverings increases the ability to increase energy loss at junctions so that LSF coating system has a damping ratio 5% to 6%.

Conclusion

According to the issues raised in the previous sections, and examples of different projects and systems using steel and concrete LSF system was introduced, the following results are obtained:

- According to the statistics of the number of housing units needed by organizations and institutions in the country, in order to provide housing for about 5.1 million housing units built annually in the country that reaching this figure using traditional construction methods, these methods are not feasible due to low efficiency and speed. Therefore, the government needs to pay special attention to this issue by creating the necessary plant and equipment, grounds for the application of advanced technologies and new methods in the construction industry countries.
- According to the estimates of the amount of steel produced in the country and the practical and scientific competencies in the country to use the system of building new LSF, now the possibility of making an annual one hundred thousand housing units using the technology LSF, which is based on the results of this research, making this the number of residential units in the system instead of conventional steel structures, steel and concrete consumption at least 200,000 and 1,500,000 tons, respectively reduced. The use of LSF for wasting very little construction materials

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in the project in addition to saving significantly on consumption of building materials and avoid wasting national resources, due to not generate construction waste to protect and preserve the environment would be very effective.

- The results show that using LSF has seismic appropriate performance due to its ability for reducing the relative location, reducing structural weight by approximately 40% greater than the metal currency, reducing the consumption of concrete by about 60% compared to concrete structures common and 30% greater than the metal current performance. By examining the differences numerical design criteria between systems LSF and popular system for building the country, confirms the fact that to achieve lightweight particleboard effective use of its advantages, the system LSF significant feature is very convenient, yet safe, which is the proper use mobile with its indigenization and training systems decision-making in various sectors, including building and housing Research center is recommended.
- Use of cross bracing on both sides of the wall increases the strength of the wall. In addition, the use of bracing on both sides due to the symmetrical distribution of the load on the column and prevent the occurrence of which will twist or distortion. Of course, the use of braces on the inner side of the operation panel thin wall work a little difficult. This issue when using square plate to connect braces will be more sensitive.
- Use double column panels will increase the load capacity. Since the teachers are vertical loads and the bracing force vertical component is added to the force, the use of double column panels will increase the load capacity. Because the connection is not used often in connection bracing plate, the central problem in connecting bracing members of the bolts Fences automatic arrangement of space that adding an additional column this problem will be resolved.
- Due to the increasing development of industries in developing countries and the lack of primary sources and the need to save energy, meeting the needs of existing and new jobs must fully comply with the criteria of sustainable development and green jobs.
- A large part of the country's population comprises of young, educated. According to people familiar with the knowledge and advanced technologies, it is fitting that innovation in creating jobs for this generation and application of new industries should be considered.
- The construction industry is one of the most desirable and economical manufacturing industry which is a significant contribution to employment and gross domestic product.

- Housing is a critical need for a large part of the country's national wealth and its deficiency imposes huge costs on household expenses basket. Now shortage in housing units needed in the country is two million units annually, 5.1 million of this amount will be added. The number of housing units per year based on current construction methods should not be possible unless using modern methods of construction.
- LSF Building System is an advanced system building from 1990 was used in the mass production of housing and it is currently used in many countries. Due to many advantages including economical, high-speed performance, light weight, safety and good resistance against earthquakes and other natural hazards, this system is compatible with environment, simplicity and ease of implementation, there is no need for heavy equipment and sophisticated and full compliance with regulations related to energy saving by traditional methods of construction.

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