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Research Paper

The Effect of Fire after Earthquake on Bending Steel Frame Structures

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ABSTRACT: *Increase in the level of structural damage, following the fire after the earthquake could cause damages more than the face of the earthquake alone. Because the fire after the earthquake includes several fires at the same time and is complex which occur due to the earthquake and can cause social and economic damages. Experience gained from past earthquakes showed that steel structures were very vulnerable against the risk of fire spread. If a steel frame placed under high heat, quickly due to reduced mechanical properties of steel at high temperature its safety seriously threatened frame. Steel frames have been formed of beams and columns that are connected by the connections. Therefore, one of the most important components of steel structures that transmit force of members to each other and mainstays are responsible for connections among members. Strong earthquake can cause significant damages to infrastructure and possible structures of the urban areas. Past events have proven that lack of attention created a lot more damages than the earthquake itself and will cause catastrophic accidents with high fatalities and casualties. This article intended to review the effects of fire after the earthquake on steel frames. In order to collect data, two methods of use of library and documents searching and sources were used to identify different aspects of the topic and the results were presented.*
Keywords*: fire after the earthquake, fire, earthquake, steel moment frame*

I. INTRODUCTION

The adverse impacts of earthquake risks become cleared with primary and secondary damages to urban structures. The most important secondary hazards of earthquake is fire. Studies have shown that sometimes damages resulting from fire could be worse than the damages of earthquake itself, and its reason is synchrony of fire and earthquake that are of two serious dangers for structure during earthquake. Also in terms of structural behavior of under earthquake loads is more important, because when structures under major earthquakes, enter to restricted plastic functional, their load capacity decrease (Kirby, 1998). By exposing to fire, of such structure, possibility of destroying of stability increases and the time of structure permanency decreases. This issue is important in buildings with steel structures, because the mechanical properties of steel quickly deteriorate by increasing temperature. In the event of a fire in a steel frame after the earthquake, the negative impacts will be far worse (Bravery, 1993; Martin et al, 1998). So, investigating the steel frame behavior at high temperatures after the earthquake can do special assistance to understand how the behavior of the frame is.Considering the different behavior of steel at high temperatures and mechanical properties of steel, class locations and legs of columns are also important. So that vertical displacement of classes depend on the temperature and increase by increasing the number of classes. However, the horizontal displacement of classes depend on the characteristics of earthquake actions and behave in appropriate with it. Lateral force of the foot of the column in the heat after the earthquake and heat without earthquakes in a short time reaches to its maximum volume and then by decreasing mechanical properties of steel decreases (Alder-ighi and Salvatore, 2009; Behnam and Ronagh, 2013). According to the given description, the main aim of this article was to examine the effect of fire on steel moment frame structures to help understand the behavior of the frame.

II. METHODS AND MATERIAL

Data collection was carried out by library (documents) searching during which the various aspects of library resources and documents for identification of the subject was used. Methods for data collection included the library searching, books, articles, dissertations, Internet and in field study, the documents were available.

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III. DISCUSSION AND CONCLUSION

Fire is always a serious threat to all aspects of human life and is an environmental factor detrimental to the structure every year in most countries that cause loss of life and damages, heavy financial losses to residential and commercial buildings. In terms of economic losses, structure damages are very high and the repair of such structures requires a high economic burden that in most cases is higher than the amount of cost to prevent the occurrence of damage, and as the loss of life is more important than financial losses. The main aim in designing structures that are exposed to fire, is to void failures and structural damage at high temperatures (Christian et al, 2004) [4]. One of the other important issues is the occurrence of post-earthquake fire that in most cases due to fire damage after the earthquake, has severe damage than the earthquake itself. Given the fact that Iran is one of the most earthquake-prone countries in the world, the damages to municipal power plant and gas pipeline during an earthquake could cause a fire; so that the damages caused by the fire burn more than earthquakes themselves. Many of collapses create due to loss of cover of damaged structural members and deformation and resulting residual earthquake stresses (Yassin et al, 2008). Therefore, in the last two decades, design and retrofit of structures against fire was considered in structural design standards and specific regulations were considered to this case (Badamchi, 1393). Steel frame have been formed from beams and columns that are connected by the connections. One of the most important components of steel structures that transmit force members to each other, are mainstays that are responsible for connections among members. The total yield structural steel joints affected behavior in structural analysis should be considered. Also, a little attention on the failure of the majority of steel structures under different loadings, it can be understood that a weak connection can be a determining factor in the failure of steel structures (Wald et al, 2004). Depending on the type and location of the connector damage it can cause local damage or malfunction of total progressive collapse of the structure. After the collapse of the World Trade Center in collisions between aircraft and fires it, it can be seen that even if the structure can be subjected to earthquake loads and loads unconventional, such as the giant aircraft proper conduct of the show, it is still very weak in front of the fire afterwards (SAC Joint Venture, 2000). Cities with high density of wooden building or buildings with high ranged of damaged and also, cities with distribution network of natural gas or pressurized air power network are more vulnerable to earthquakes and fires are one of the most important secondary hazards. Fire after the earthquake includes complex and synchronic fires at the same time and a large number that occur due to earthquake and can cause extensive socio-economic damages. For example, fire after the earthquake that occurred in the past and had significant and devastating consequences, can be pointed as the fire of 1906 in San Francisco. Of the researches on fire after the earthquake, can mention research on the risk of its occurrence and modeling how to extend and extinguish it from the perspective of fire and often less attention has been given to the effect of construct of buildings fire (Behnam and Ronagh, 2014).Also from the point of view of structural, structural behavior, is more important, because when large structures are under earthquake their capacities decrease.

If such structure exposes to fire, the possibility of loss of stability increases and the durability of the structure decreases. This feature of structure is important in steel structure because by increasing temperature the steel quickly deteriorates. Of the researches that has been done about effect of fire after earthquake on steel structure behavior, can mention to Delakorte et al (Mousavi et al, 2008). In this study, the behavior and flexural strength of steel frame in front of the fire after the earthquake was investigated. Another study by Yasin et al in the performance of steel frame under fire after the earthquake, was carried out. Analysis of frames, two-dimensional steel in this study showed that the behavior of these frames under fire after the earthquake strongly affected by lateral deformation caused by the earthquake in the frames (Raul Zaharia and Dan Pintea, 2009).Studies showed that although steel elements that are covered with fire insulation, have good performance against normal fire nor fire after an earthquake and this issue delays the collapse of the steel structures of the elements. This coating may be vulnerable for elements that are exposed to earthquakes and lose their protective role. Under fire after the earthquake, the earthquake steel members for load-bearing of earthquake enter to their performance range of plastics and plastic hinges in beams and columns are formed. This leads to cracking of cover position of fire resistance on the plastic hinge in these members and their mechanical properties decrease rapidly (Fig 1).

Figure 1. The collapse of fire insulation cover in place of plastic hinge [12]

According to previous studies, in relation to the fire after the earthquake, structure in point of sufficient cover attention in different conditions has been considered (Memari et al, 2013). Basically, performance of structures after the earthquake against fire depends on several parameters. In addition, a lot of uncertainty in predicting the mechanical behavior of structures are located under the load. One of the main issues under such circumstances, is to estimate reliably the building structure, after the earthquake. Structural situation after the earthquake, will be the initial conditions of the structures for loading the fire after the earthquake. Structure that will be affected by the quake, suffered two injuries of geometric and mechanical damages. The lateral displacement that indicates of the highest displacement, with regard to the history of earthquake duration in structure can to be constructed, that is very important. In addition to mechanical damage as well as changes in the mechanical properties of materials of structure that enter from that to plastic range, are considered. The fire load to study the effects of fire on steel structures, fire resistance capability to construct various elements must be taken into account (Yahyai and Hasanpour Ghamsari, 2012).In the special bending frame steel structures, due to the large formation, under severe earthquakes can significant permanent transfer that under the effect of these displacements, structural strength against fire after the earthquake compared to non-injury, reduce significantly. Therefore, this issue could be considered in the design of these frames (FEMA356, 2000).Thus, it can accelerate the damage caused by the earthquake in the building in addition to the structural, non-structural damages (Zaharia and Pintea, 2009).Experience obtained showed that steel structures against the risk of fire spread are very vulnerable. If a steel frame placed under high heat quickly due to reduced mechanical properties of steel at high temperature, its safety seriously threatened frame. In the event of a fire in a steel frame after the earthquake, the impact will be far worse. For this reason, the behavior of the steel frame in high temperature after the earthquake could be of great importance to understanding the behavior of the frame (Della Corte et al, 2003) [17].Despite the many benefits of steel construction, steel sensitivity to temperature is one of its most notable weaknesses. Mechanical properties of steel at high temperatures decreases significantly (Fig 2).

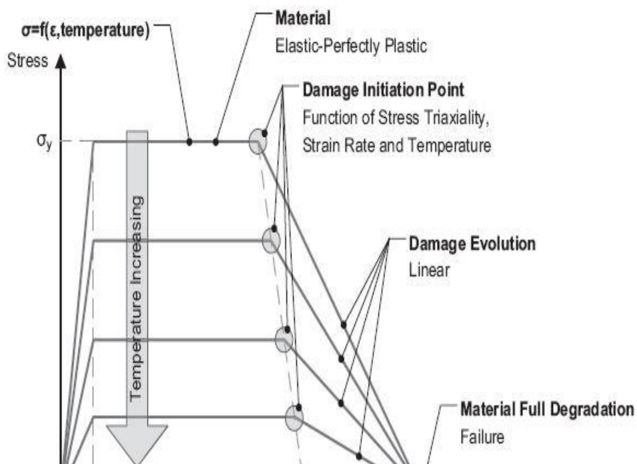

Figure 2. How to change the behavior of the steel with increasing temperature [18]

Due to the lack of heating steel to simulate the effects of fire on steel structures is of great importance. therefore, in the last two decades, design and retrofit of structures against fire have been studied and taken into consideration in the design codes of structures, and specific criteria to this case was considered (Yasin et al, 2008).Because of the recent attention of researchers to more past due to the fact that the standards and regulations, perhaps ignore under fire after the earthquake (Borden, 1996).Since the probability of failure of a structure fire and lateral loads resulting from earthquakes are not properly designed, so danger of structure that has minor damages caused by the earthquake under fire after it exist. Fires after the earthquake should be considered as a structural loading with high possibility that needs more investigations and should be mentioned in structural standards (Mohammadi, and Alysian, 1992).There are several historical examples where fires after the earthquake led to significant losses, some of them included Kobe earthquake in 1995 and 1933, the Tokyo earthquake of 1906 and the San Francisco earthquake in 1989. Since the occurrence of an earthquake and subsequent events cannot be prevented, proper design can minimize injuries and damages. In severe earthquakes, buildings designed for seismic zones, may experience plastic deformation without collapse. However, such an earthquake with starting a fire may be uncontrollable and causes damage to the main water networks and gases. Once upon earthquake, fire occurs in buildings with stiffness decreased due to the earthquake, may have the capacity to withstand extreme events after an earthquake such as fire (Chen et al, 2004).So, fire after the earthquake is a threat that carefully should be considered as the damages caused by the earthquake vulnerability increases damages to structures against fire that is due to the transformation of waste and reduction of the strength and stiffness caused by the earthquake in structure affected by fires (Gupta and Krawinkler, 1999).Previous researches on the performance of structures in fire after the earthquake have investigated the subject through the issue of certain (fixed) and in different programming environments for seismic and thermal analysis. Ignoring drop of materials resistance after the earthquake would reduce the accuracy of the results. The second concern is that although performance-based seismic design guidelines are as good as new ones and to a large extent the regulations have been developed, however, the current fire design methods, are relatively common prior or performance-based instruction and these guidelines require certain input variables (modal).However, available information suggests that there are a lot of uncertainty defined densities, once fire and properties of materials at high temperatures. Therefore a method based on reliability assessment of structures in fire is required (European Committee for Standardization, 2005a).

IV. CONCLUSION

Based on the discussions, it is concluded that in steel structures, many factors depend on resistance against fire after an earthquake such as factors created as various seminars of fire, there are also the effects of loading cycle including new topics and arguably considered as the last word that can be noted in steel structures that are very different behavior and unpredictable in the fire after the earthquake that need more research in this field.

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