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INVESTIGATION OF THE PROGRESSIVE COLLAPSE IN THE MIDDLE HEIGHT STEEL FRAMES SUBJECTED TO FAIL OF COLUMNS

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Abstract

Many of the available non-static loads are vulnerable to loads such as explosion load in the design of such loads and therefore their resistance to such loads should be increased. When the explosion occurs, a very rapid energy explosion is released as light, heat, sound and a wave of radiation. The damage caused by the X wave is in two cases; the direct effects of explosion and the effects of progressive collapse. Considering the above mentioned conditions, immunization. Of utilities against the effects of explosion is very important, especially in the case of structures which are in importance in position of specially. In particular, due to the occurrence of terrorist attacks in some of the most important buildings, the structure must have acceptable resistance against these loads .in this study, to investigate progressive collapse in steel structures with dampers in connection of beam to column in the first floor, the method of library studies and Abaqus software was used for modelling. The results of this research show that by creating a damper in the first - floor connection, it has a positive effect against the progressive collapse on the structure so that in some cases, offset the system by 50 percent and prevent further destruction

Keywords: Progressive collapse, Explosion, Damper, Column, Beam

Introduction

Over the last decades considerable attention has been raised on the behavior of engineering structures under blast or impact loading. The use of explosives by terrorist groups around the world that target civilian buildings and other structures is becoming a growing problem in modern societies. Explosive devices have become smaller in size and more powerful than some years ago, leading to increased mobility of the explosive material and larger range effects. Usually the casualties from such a detonation are not only related to instant fatalities as a consequence of the direct release of energy, but mainly to structural failures that might occur and could result in extensive life loss. Famous examples of such cases are the bombing attacks at the World Trade Center in 1993 and on the Alfred P. Murrah Federal Building in Oklahoma City in 1995. In both of these incidents, structural failure, including glass breakage, resulted in far more victims and injuries than the blast wave itself. After the events of the 11th September 2001 that led to the collapse of the World Trade Center in New York it was realized that civilian and government buildings, as well as areas with high people concentration (metro and train stations, means of mass transportation, stadiums etc.) are becoming potential bombing targets of terrorist groups. Since most engineering structures are vulnerable to such type of loading scenarios, a guide should be introduced to the designer in order to guarantee structural integrity even under those extreme situations. The problem of structural resistance under explosive loads has been under investigation for many years and has been well advanced in the military community. This is also the reason that the majorities of these findings are not accessible to the public and are only restricted to military use. Nevertheless, some documentation that allows the prediction of the effects of an explosive blast is available for use by design engineers. The Eurocode EN 1991-1-7[1] makes reference to the case of accidental loads and explosions, but it is mainly focused on impact actions, such as collisions from trucks, trains, ships, helicopters or any other vehicle in general. Reference is also made to gas explosions that take place in enclosed spaces but an overall approach for design under blast external loads is still missing. Some design strategies are also recommended aiming to ensure increased robustness in building structures that are to endure localized failure. However, no guidelines are provided in [1] for the calculation of external blast induced loads.

Blast Loading

When loads of energy is added to the structure in a very short time and in the limited space, the load is called the explosion. One of the threats to the urban environment is the blast in these areas. The estimation of the loads caused by the explosion and conditions under which the load is applied is one of the major arguments in analysing the effects of blast effects on the structures. To investigate the effects of the explosion on the structures, it should have a correct understanding of the effects of the explosive charges on the material that constituent elements are. The huge loads which are applied in the short-term time range are not included in the divisions of static and dynamic loads [3]. Because of the impossibility of all-out experience of blast in many cases, computer programs will help and obtain accurate simulation. Knowledge of these cases will be useful in the analyses and the works carried out in this regard. Under dynamic loading of the concrete structure, cracking, brittle fracture, and structural powder occur [2]. All of this process can lead to preliminary images in the elastic range of material, on plastic deformation and the formation of small cracks, crushing to small pieces and finally to grainy or powdered. Generally, the ability to tolerate the load and energy absorbed by the structure is the expression of a hypothesis or changes in the length of the process. This hypothesis plays an important role in determining the performance of structures. Concrete has been used to create resistance to damage and prevent damage in building structures such as bridges, tower, dams and etc [4,5]. However, there is no clear understanding of the parameters affecting the resistance and shape of these structures under an explosive load [7].

Introduction Modeling examples

In order to avoid the design of beam and column design, in this study, the plan, number of floors and sections of the beam and columns were similar to the model in [6]. In this section, the selected plan presented in figure 1 and also the beam and column sections in table 1 are modeled in the Abaqus finite element software. However, the roof system has been selected as compound, that is, at the bottom of the steel roof, above the concrete slab. It is also quite rigid connections.

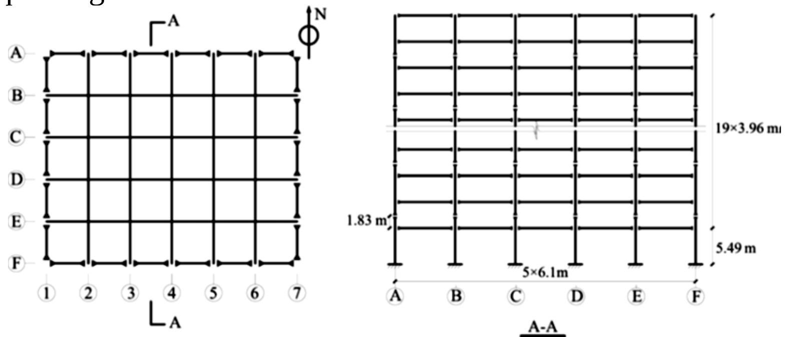

Figure 1: Plan of structure

Table 1. Characteristics of beams and columns

	Storey	Section	Depth of cross section (mm)	Width of cross section (mm)	Thickness (mm)	
					Flange	Web
Beam	1-4	W30×99	753.1	265.4	17.0	13.2
	5-10	W30×108	757.7	266.1	19.3	13.8
	11-16	W30×99	753.1	265.4	17.0	13.2
	17-18	W27×84	678.4	253.0	16.3	11.7
	19	W24×62	603.0	178.8	15.0	10.9
	20	W21×50	529.1	165.9	13.6	9.7
Corner column	1-2				50.8	
	2-5				31.8	
	5-14	ASTM A500	380	380	25.4	
	14-19				19.1	
	19-20				12.7	
Interior column	1-5	W24×335	699.0	343.4	63.0	35.1
	5-11	W24×229	660.9	333.0	43.9	24.4
	11-14	W24×192	646.9	328.9	37.1	20.6
	14-17	W24×131	621.8	326.5	24.4	15.4
	17-19	W24×117	616.2	325.1	21.6	14.0
	19-20	W24×84	612.1	229.0	19.6	11.9

Result

In the table 2, the properties of the investigated samples include the column removal site and the number of the playoff columns and all states have been analysed once for a simple and one- time mode with damper application.

Table 2. Properties of the investigated samples

Number	Name	The numbers are down	The pillar position is broken
1	A3	1	**middle**
2	A4	3	**corner**
3	A5	3	**corner side**
4	A6	1	**corner**
5	A7	1	**corner side**
6	A8	6	**corner**

Example A3 (column in the middle of the structure)

An example is the removal of the middle column, which is a non-damper mode and a state with damper, which in Figure 2 indicates the location of the destruction and elimination of the column. Figure 3 illustrates the right side of the specimen with damper and non-damper in the beam connection to the column compared in Figure 4 of the structure of the structure in this model.

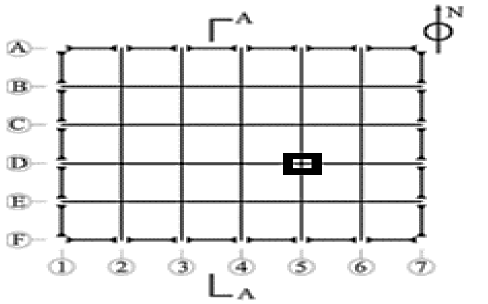

Figure 2: The position of removal of the column (Middle column - Ground floor)

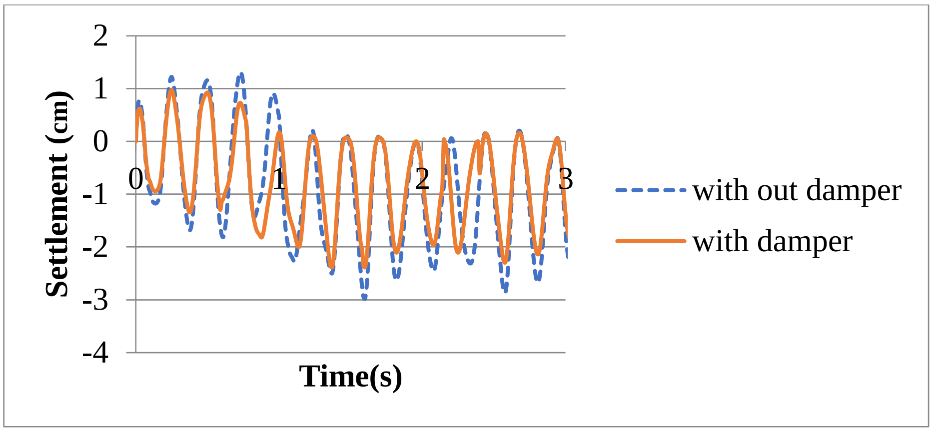

Figure 3: Settlement of A3 in broken column

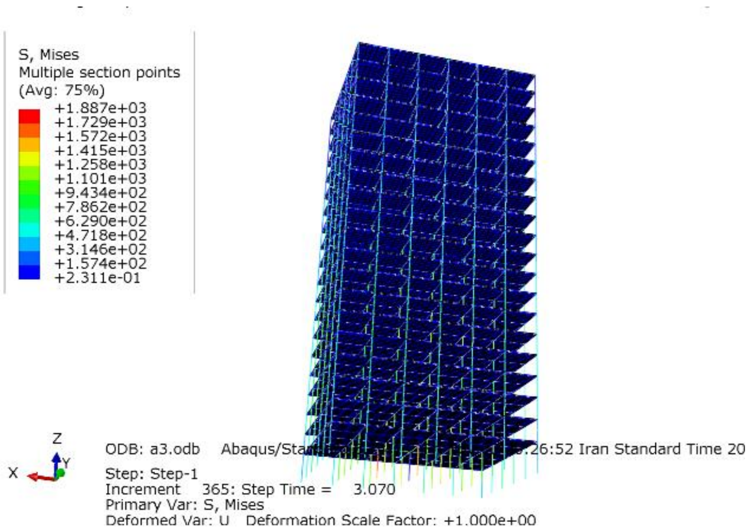

Figure 4: Stress in building in A3

Example 4 (effect of columns number)

An A4 example is the elimination of the middle column, which is a non – damper mode and a state with damper, which in Figure 5 shows the location of the destruction and the removal of the column. Figure 6 illustrates the right side of the specimen with damper and without damper in the beam connection to the column compared in Figure 7 of the structure of the structure in this model.

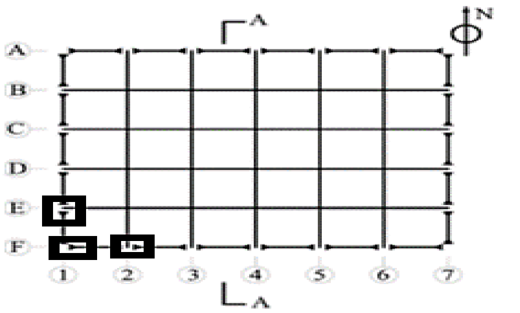

Figure 5: The position of removal of the column A4

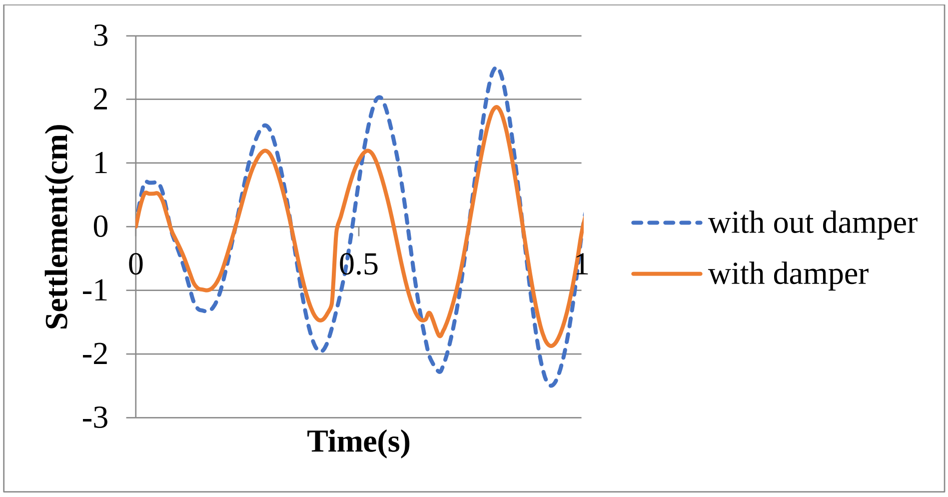

Figure 6: Settlement of A4 in broken column

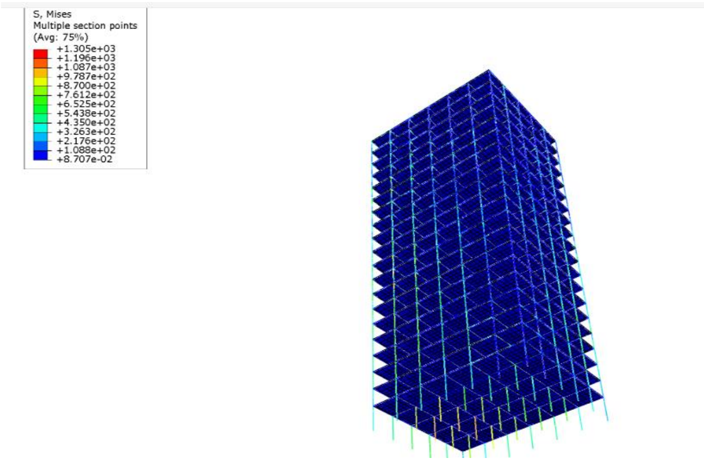

Figure 7: Stress in building in A4

Example 5 (effect of middle columns)

An A5 example is the elimination of the middle column in side, which is a non – damper mode and a state with damper, which in Figure 8 shows the location of the destruction and the removal of the column. Figure 9 illustrates the right side of the specimen with damper and without damper in the beam connection to the column compared in Figure 10 of the structure of the structure in this model.

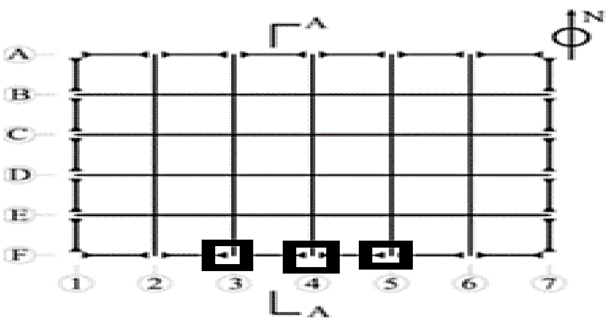

Figure 8: The position of removal of the column A5

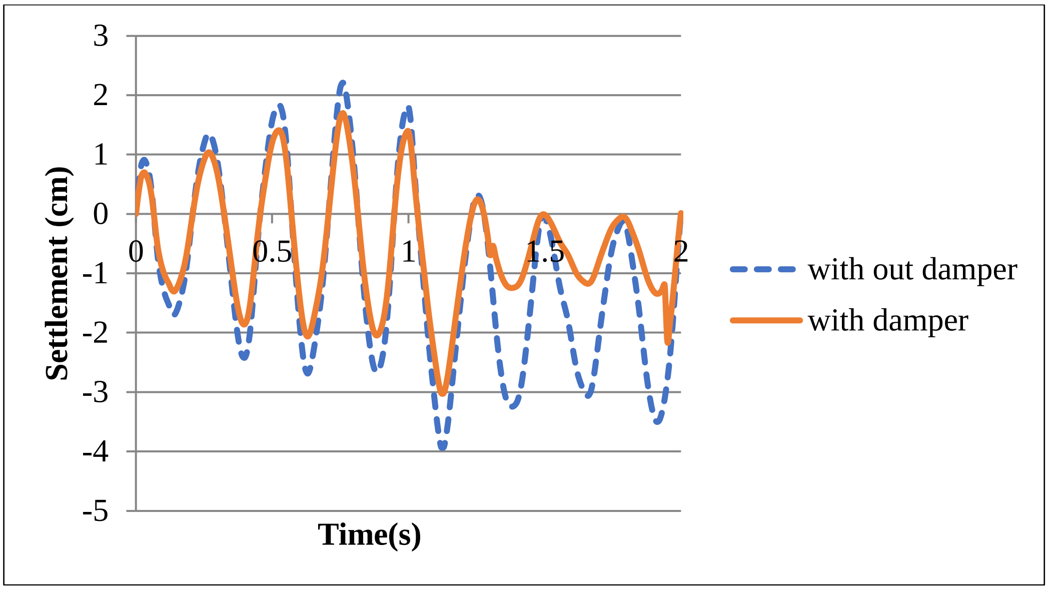

Figure 9: Settlement of A5 in broken column

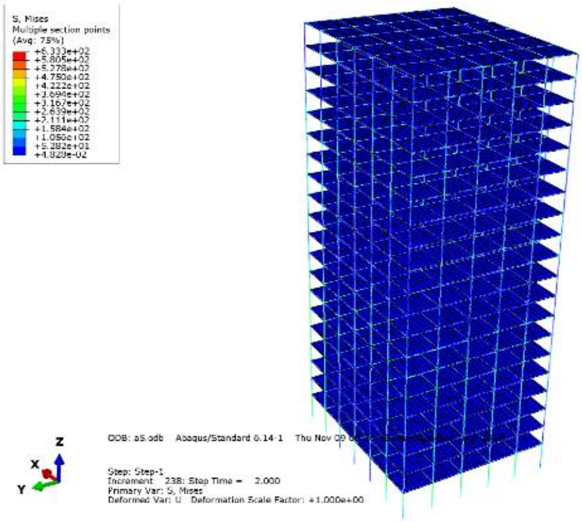

Figure 10: Stress in building in A5

Example 6 (effect of one corner column)

An A6 example is the elimination of the one corner column, which is a non – damper mode and a state with damper, which in Figure 11 shows the location of the destruction and the removal of the column. Figure 12 illustrates the right side of the specimen with damper and without damper in the beam connection to the column compared in Figure 13 of the structure in this model.

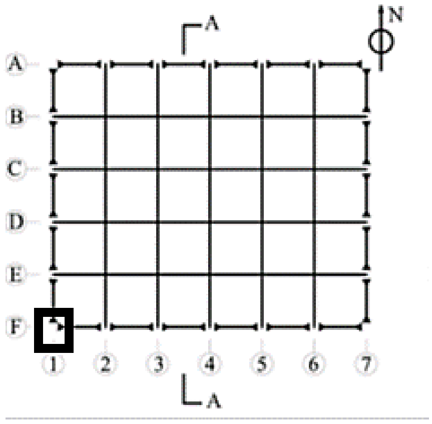

Figure 11: The position of removal of the column A6

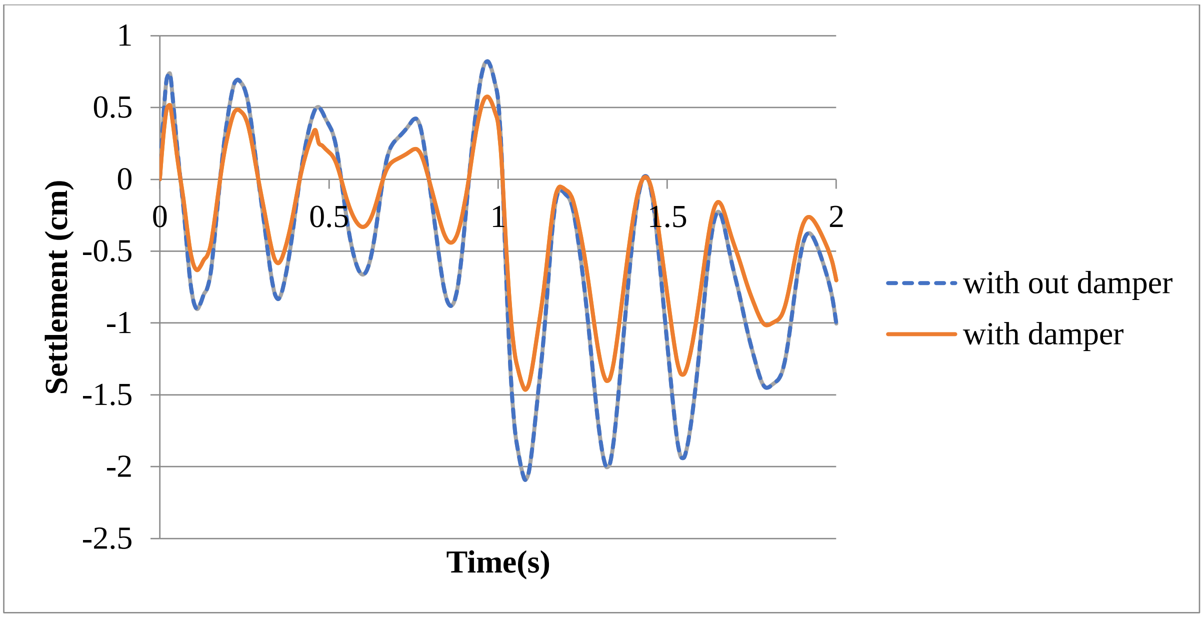

Figure 12: Settlement of A6 in broken column

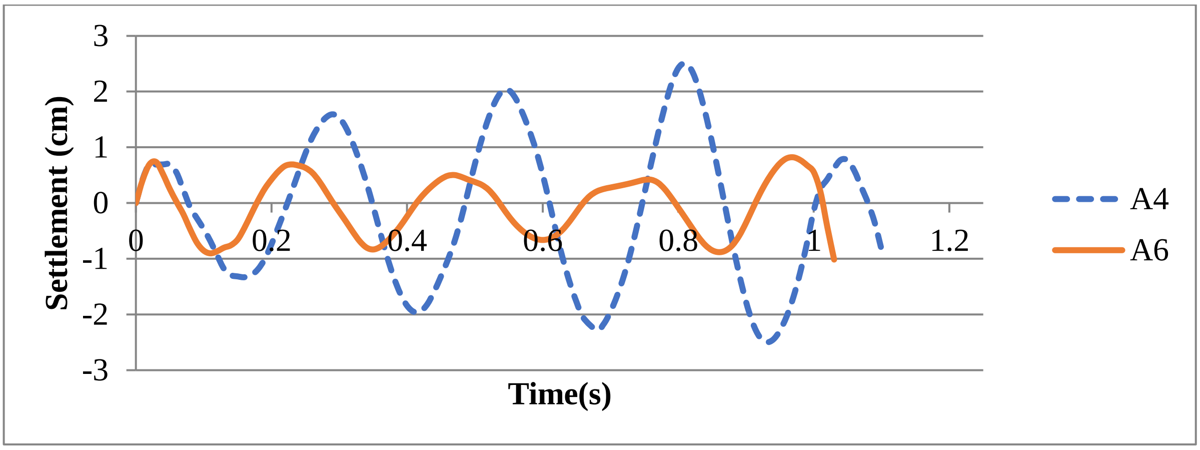

Figure 13: Comparison of A6 and A4.

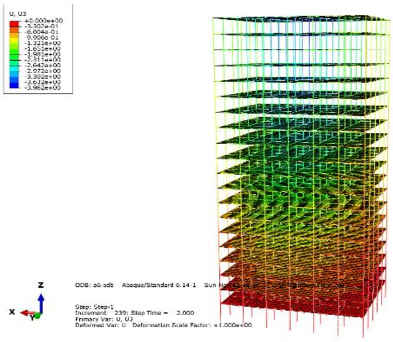

Figure 14: Displacement in building in A6

Example A7 (effect of Single Side column)

The A7 example is the removal of a side column, which is a non – damper mode and a state with damper, which in Figure 15 shows the location of the destruction and removal of the column. Figure 16 illustrates the right side of the specimen with damper and non in the beam connection to the column compared in Fig17 shows the shape of the structure in the model, and in Fig 18 the elimination of one column and three columns are compared.

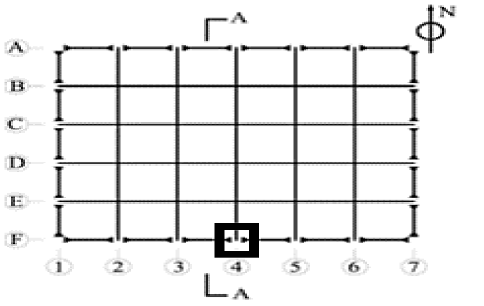

Figure 15: The position of removal of the column A7

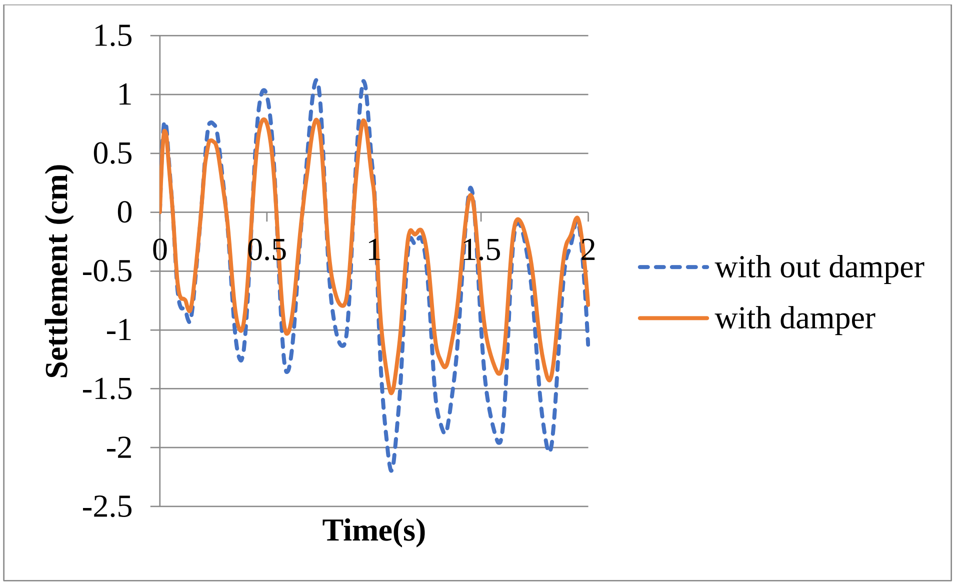

Figure 16: Settlement of A7 in broken column

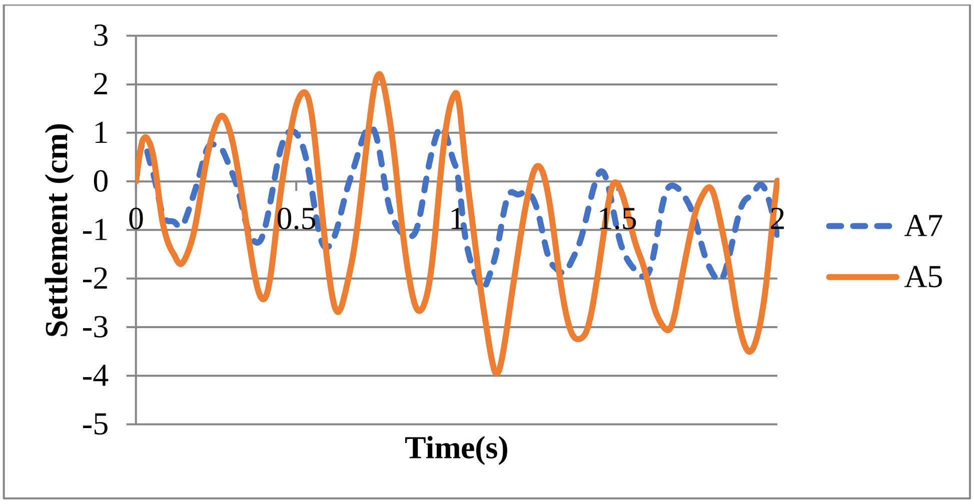

Figure 17: Comparison of A5 and A7

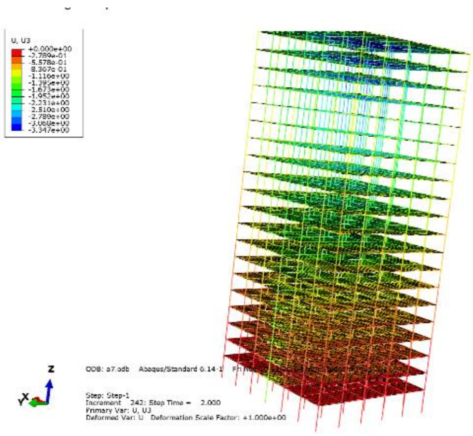

Figure 18: Displacement in building in A7

Example A8 (effect of Single Side column)

The A8 example is the removal of six corners, a state- free mode and a state with damper, which in Figure 19 indicates the location of the destruction and removal of the column. Figure 20 illustrates the right side of the specimen with damper and non - damper in the beam connection to the column compared in Fig 21 of the structure of the structure in this model.

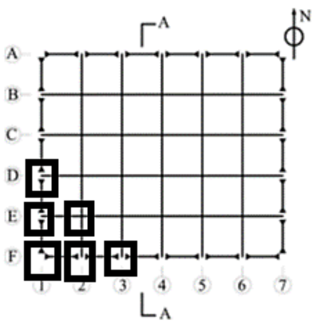

Figure 19: The position of removal of the column A8

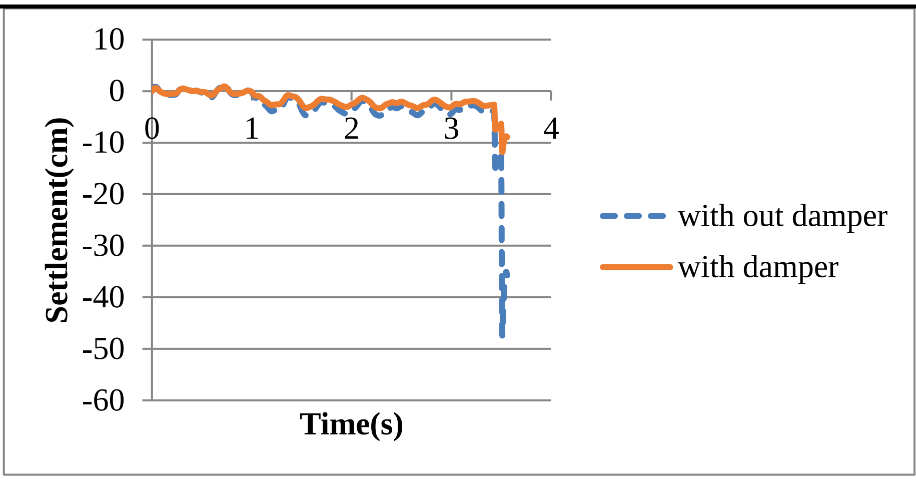

Figure 20: settlement of A8 in broken column

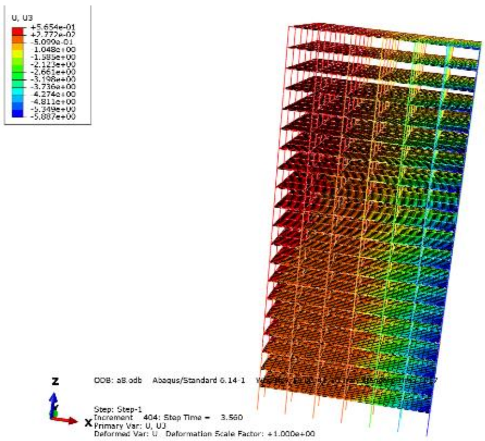

Figure 21: Displacement in building in A8

Conclusion

Based on research, the following results can be extracted:

- The effect of damper in the control of the structure in different samples is about 30 to 50 percent. With increasing the number of columns omitted in the structure the structure is investigated further and with the elimination of six columns to its progressive breakdown.
- The A8 sample delayed only a few progressive failures by removing damper six columns by applying.
- The removal of the column in the middle mode has produced less vertical displacement than any other columns.

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