Novelty Journals

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences
Vol. 2, Issue 2, pp: (23-28), Month: May - August 2015, Available at: www.noveltyjournals.com

Effects of Material Strength on Structural Performance for the Irregularity Structure

[1]Ercan IŞIK, [2]Cevat KAYA, [3]Taha TAPANCI

[1]Bitlis Eren University, Department of Civil Engineering, Bitlis, Turkey
[2,3]Civil Engineer, Bitlis, Turkey

Abstract: **The material strength is one of the components of the performance of an engineering structure. In this study, effects of material strength on structural performance of reinforced concrete building which had A3 structural irregularity was investigated with SAP 2000 Structural Analysis Program. Concrete and steel have been selected as two different variables. Calculations have been made for each concrete grade which was selected as C16, C18, C20 and C25. S220 and S420 steel grades were taken into account. As a result, structural behavior of RC buildings which had A3 structural irregularity with different concrete and steel grades were compared and evaluated according to analysis results in detail. The displacement and internal forces obtained from results of analysis different steel and concrete grade is investigated comparatively. The base shear of building was increased according to increasing strength of steel and concrete. The peak displacement of building has been increased according to increasing in base shear. The goal of this study was investigate the importance of strength of materials on structural performance of reinforced concrete structures. The values that have taken into account for the materials in the calculation of the buildings must be provided in constructions also. Workmanship, material and control mechanism factors have a special importance for strength of engineering structures in application.**

Keywords: **Structural performance, concrete, steel grade, strength, A3 structural irregularity.**

I. INTRODUCTION

The importance of studies, researches and prevention about earthquake have risen after destructive earthquakes in the world especially in recent years. Earthquake damages will increase according to vulnerability of urban and rural building stocks. The size of earthquakes and negative structural features will be caused an increase in damage amount. Knowing the properties of buildings materials that have been negatively influenced to the seismic behavior of buildings under earthquakes will be put forward to ensure more serious approaches to reduce the level of damage risk after earthquakes.

In order to reduce the damages of the earthquakes the performance of buildings needs to be determined. Earthquake safety of existing buildings has gained considerable importance after earthquakes especially in the last 30 years. Performance based assessment methods have been widely used for existing reinforced concrete structures.

Reinforced concrete (RC) is a composite structural material that combined by steel and concrete. Concrete with its compressive strength and steel with its strong tension strength have formed RC material. The compressive stresses were covered by concrete and tensile stresses were covered by steel in the structures was revealed RC materials. Steel and concrete combined for response to loads together. Any defect in concrete or steel element affects all of the structures. The adherence between steel and concrete improves properties of RC structures. The first defect was usually related with materials that used in RC buildings that damaged after an earthquake.

Impacts of concrete and steel grade on the selected building has been compared and analyzed. At the end of the analysis of their impact on the structure of concrete and steel grade selected it has been compared and analyzed. Comparison was made at the end of study for each variable. The main objective of this study is to assess the seismic performances of the selected building by the linear elastic and non-linear evaluation procedures using different concrete and steel grades. After the assessment, an evaluation can be done from obtained results. The results are compared to each other. SAP2000 software is used for calculations [1].

II. DESCRIPTION OF THE BUILDING

Analyzing structures using various material strengths is important to obtain performance of structure under earthquake. For this purpose, an irregular structure of in plane (A3 type) and 4 stories is considered. 5 axes in X and Y direction was selected (Fig.1).

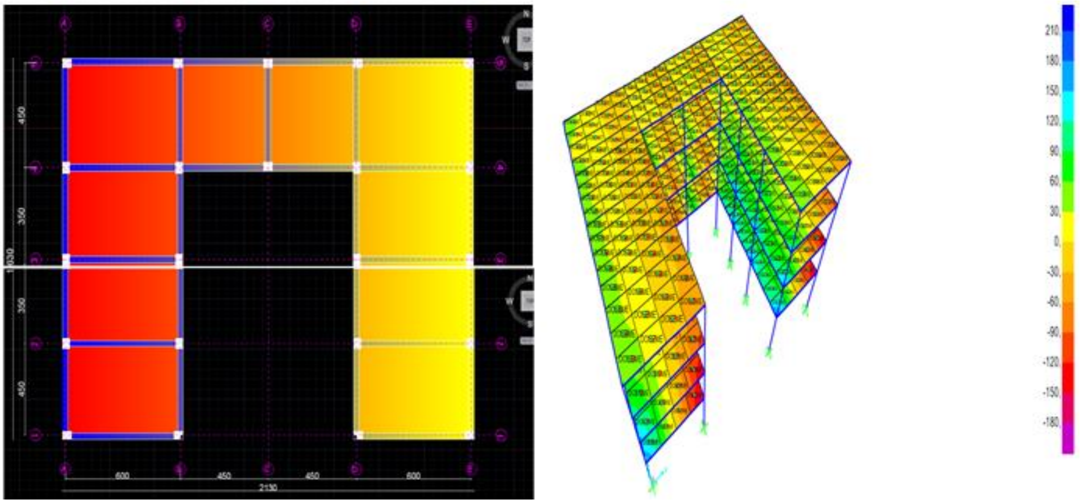


Fig. 1. Plan of selected building

This consists of a typical beam–column RC frame building with no shear walls, located in a high-seismicity region of Turkey. 4-story building is designed according to Earthquake Code, considering both gravity and seismic loads (a design ground acceleration of 0.3g and soil class Z2. The ground story height is 4m and the other story heights are 3.5m. Total height of structure is 13m. Building is 16x21m in plan. The dimensions of columns are 0.4 m ×0.5 m. All beams are T-shaped and their dimensions are 0.3m × 0.6 m. The effective width of the beams is calculated according to TS500 [2]. The height of floor was 0.14m. The vertical loads consist of dead and live loads of slabs, wall loads on beams and dead loads of columns and beams.

III. METHODOLOGY

Looking at the history of earthquake damages in Turkey, it can see that most of typical damages were due to architectural design. Earthquake codes gain an important role for design maker.

There are various factors that should be taken into consideration when the criteria of the seismic design in Turkey are determined. There is a strong relationship between the architectural design of a building and its earthquake safety. The dimensions of height and plan, the type and distribution of partition walls, the selection of the structural system, distribution of mass and rigidities of a building affect the earthquake safety significantly. Because of these facts, architects are advised to design regular and symmetric structures. When collapsed or severely damaged buildings are investigated, it is seen that the causes of damage are directly or indirectly related to the irregularities, developed during the architectural design. The interesting point is that there is no restriction to these irregularities in the earthquake codes although it is known that they are the main causes of severe damage [3].

The interaction of architectural form and structural configuration has become a serious issue in the building industry because of the poor seismic performance of reinforced concrete buildings in Turkey. Therefore, it has a determinative role on earthquake behavior of buildings [4].

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences

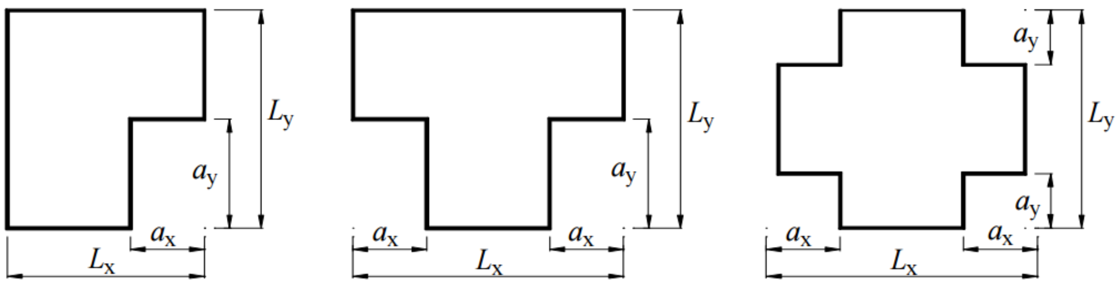
Vol. 2, Issue 2, pp: (23-28), Month: May - August 2015, Available at: www.noveltyjournals.com

Structural irregularities are described in section 2.3 of Turkish Earthquake Code (TEC2007) [5]. Regarding the definition of irregular buildings whose design and construction should be avoided because of their unfavorable seismic behavior, types of irregularities in plan and in elevation are given in TEC2007. These irregularities were given in Table 1.

TABLE: I Irregular buildings types in TEC 2007 [5].

IRREGULAR BUILDINGS
A – IRREGULARITIES IN PLAN
A1 – Torsional Irregularity
A2 – Floor Discontinuities
A3 – Projections in Plan
B – IRREGULARITIES IN ELEVATION
B1 – Interstorey Strength Irregularity (Weak Storey)
B2 – Interstorey Stiffness Irregularity (Soft Storey)
B3 - Discontinuity of Vertical Structural Elements

Architectural form determines the strength of the building because the building behavior depends on this form. If plan of the building is not consisted of simple and regular geometries there will be big stresses especially at corners of the building during an earthquake [6]. The Turkish earthquake code describes the projections in plan irregularity as follows: ‘‘The cases where projections beyond the re-entrant corners in both of the two principal directions in plan exceed the total plan dimensions of the building by more than 20% in the respective dimensions (Fig.2).”



Type **A3** *irregularity :*

$a_x > 0.2\ L_x$ *and at the same time* $a_y > 0.2\ L_y$

Fig. 2. Projections in plan (A3) drawings

It is not always possible to design a building having a symmetrical plan. In fact, most of the time, due to the requirements of the building program, functional and aesthetical concerns the architects decide to create more complex building forms. Even so, if the projections are absolutely necessary, the structural engineers should be consulted for additional reinforcements.

Material strength affects the behavior of structures under earthquake directly. RC buildings was formed the majority of the buildings in Turkey. RC buildings were formed concrete with steel material. The strength of concrete and steel material affects the performance of RC buildings.

In this study, effects of material strength on structural performance of reinforced concrete building which had A3 structural irregularity was investigated with SAP 2000 Structural Analysis Program.

IV. ANALYSIS RESULT

Based on structural dynamics theory, the modal pushover analysis procedure retains the conceptual simplicity of current procedures with invariant force distribution, now common in structural engineering practice [7]. The POA has been widely used for its conceptual simplicity, computational attractiveness and capability of providing satisfactory predictions of seismic demands for low and medium-rise structures if the inelastic action is distributed over the height of the

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences
Vol. 2, Issue 2, pp: (23-28), Month: May - August 2015, Available at: www.noveltyjournals.com

structures [8]. The pushover should be continued to the largest displacement practicable until degradation of the overall system occurs or limits of structural stability occur. In cases where a target displacement is set as a goal, it is generally worthwhile to push a little further to establish a better confidence level [9].

Calculations have been made for each concrete and steel grade selected C16, C18, C20, and C25 as concrete grade and S220-S420 as steel grade. Impacts of concrete and steel grade on the selected building has been compared and analyzed. At the end of the analysis of their impact on the structure of concrete and steel grade selected it has been compared and analyzed.

S220 and S420 steel grades were used for RC building. SAP2000 software was used for calculations. Loads were obtained same for all type concrete classes that selected in the study. Dead load for the structure was calculated as 5.02kN/m2. Live loads in the building were adopted as 3.5kN/m2 in floors; Wall loads were adopted as 4.5kN/m2. The calculations were made separately for each concrete grade. C16, C18, C20 and C25 concrete grades were used in this study.

Pushover curve of building for selected concrete and steel grades were given in Figure 3,4 .

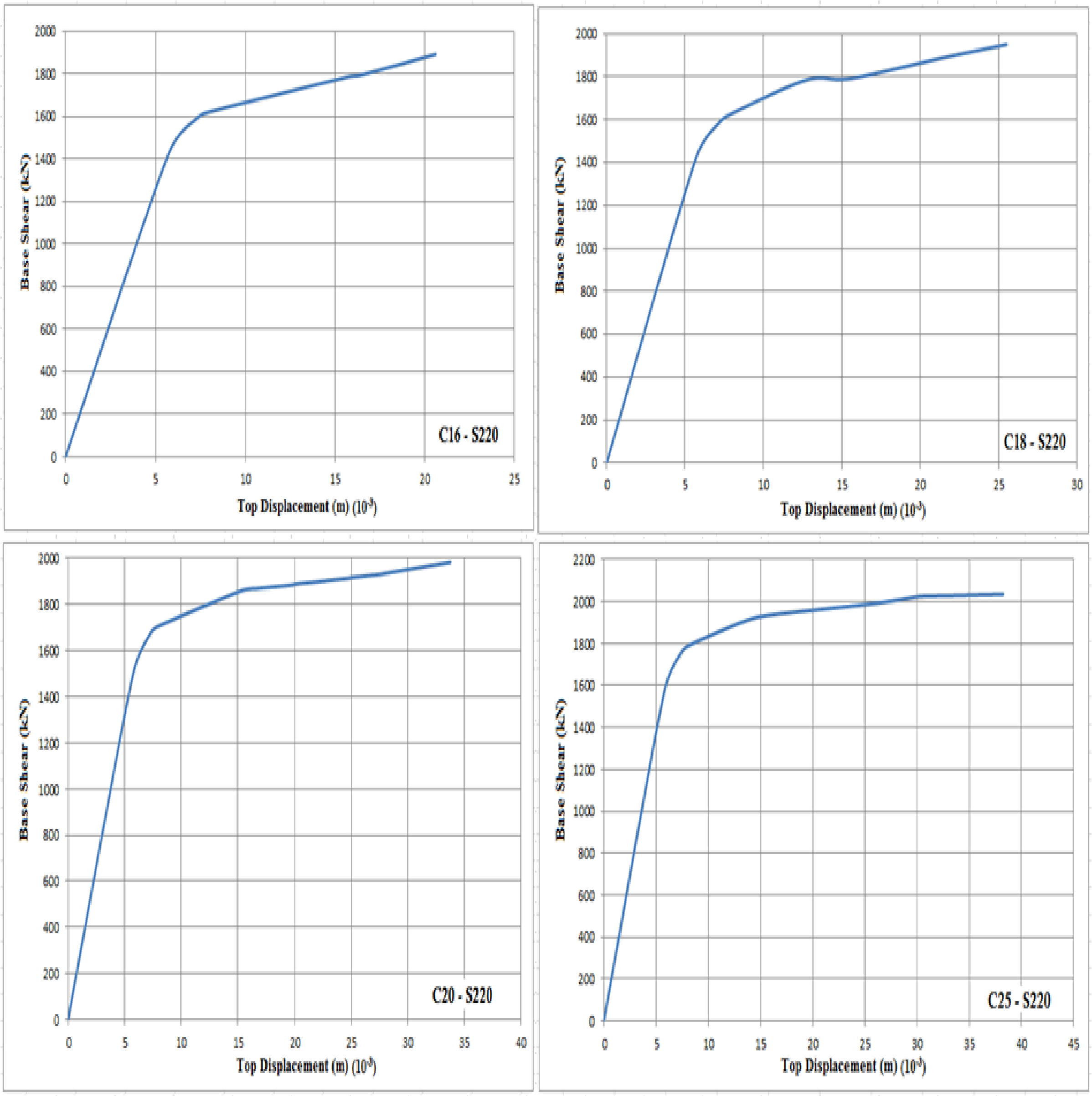


Fig.3. Pushover capacity curves of building for S220 steel grade for different concrete grad

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences
Vol. 2, Issue 2, pp: (23-28), Month: May - August 2015, Available at: www.noveltyjournals.com

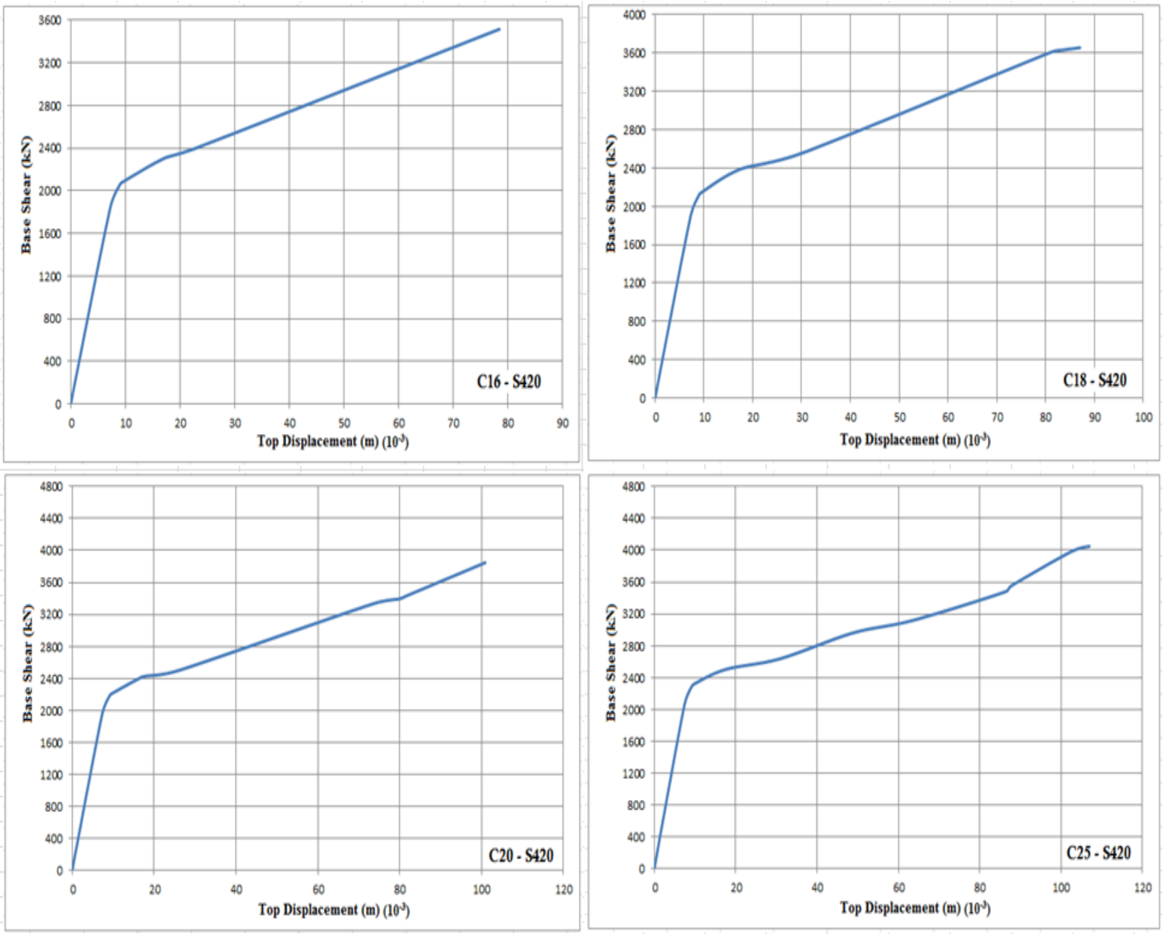


Fig.4. Pushover capacity curves of building for S420 steel grade for different concrete grad

V. CONCLUSIONS

Performance based earthquake engineering filled a very important gap in civil engineering discipline. With the performance based planning and evaluation, it is possible to determine the material losses and possible life losses and to calculate quantitatively what level of performance a building or building stock can have. In order to prevent an earthquake, to turn into a disaster where lives are lost, performance based method is used to enable decision makers to receive information on numerical data and calculations considering building performance.

In this study, A3 – Projections in Plan irregularity which is a part of the Turkish Earthquake Code and one of the important irregularities that affect the choice of methods to be used for earthquake design of building and building-like structures was investigated in detail.

Concrete is a composite material of using various materials such as aggregate, cement and water. Production of concrete is possible and easy in every way in everywhere in the world. Furthermore, step number of concrete production is very much such as calculation of composition, transportation, concreting, compaction and curing of concrete. The defects of materials that used for concrete affects concrete strength directly. Steel production was made only in factories under control. This make concrete weaker than steel. So the first defect was related with concrete for RC buildings that damaged after an earthquake.

The first defect was related with materials that used for RC buildings that damaged after an earthquake. In this study, effects of concrete and steel grades on structural performance of reinforced concrete building have been investigated.. Calculations have been made for each concrete grade which was selected as C16, C18, C20 and C25 with S220- S420 steel grades. Pushover analyses were used for both direction of selected building. As a result, structural behavior of RC

International Journal of Novel Research in Civil Structural and Earth Sciences
Vol. 2, Issue 2, pp: (23-28), Month: May - August 2015, Available at: www.noveltyjournals.com

buildings with different steel and concrete grades were compared and evaluated according to analysis results in detail. The displacement and internal forces obtained from results were given in Table 2.

TABLE: II. The results of pushover curves for different concrete classes

Pushover analysis	Material Grade							
	S220				S420			
	C16	C18	C20	C25	C16	C18	C20	C25
Base Shear (kN)	1890,33	1950,13	1993,2	2035,182	3515,37	3655,76	3847,65	4050,52
Displacement (m)	0,02060	0,02552	0,03376	0,03824	0,07846	0,08707	0,10093	0,10765

The results show that base shear of building was increased according to increasing concrete strength. The increasing in base shear has been increased the amount of peak displacement in the structure. As a result, it can say that concrete strength was not too defective. The main issue is manufacturing of concrete has not been made under proper conditions. The reason for this is lack of control, workmanship and material defects. The producing concrete with hand was given up, the ready-mixed concrete using has become widespread. In order to avoid such irregularities, the main body can be separated into regular (symmetrical in plan) blocks by seismic joints. This can be made by in two ways; the first is to divide building blocks into simple parts. The second is to tie the building wings strongly with a linkage element to reduce torsion. Due diligence must be shown in reinforced concrete construction also.

REFERENCES

[1] SAP2000, Integrated Finite Element Analysis and Design of Structures Basic Analysis Reference Manual, Computers and Structures, Inc., California, 2012.

[2] TS500. "TS500 Requirements for design and construction of reinforced concrete structures." (2000): 67.

[3] Tezcan, Semih S., and Cenk Alhan. "Parametric analysis of irregular structures under seismic loading according to the new Turkish Earthquake Code, “Engineering structures 23.6 (2001): 600-609.

[4] İnan, Tuğba. "The interaction of reinforced concrete skeleton systems andarchitectural form subjected to earthquake effects." (2010).

[5] Code, Turkish Earthquake. "Specification for structures to be built in disaster areas," Ministry of Public Works and Settlement Government of Republic of Turkey (2007)

[6] Harmankaya, Zeynep Yesim, and Asena Soyluk. "Architectural design of irregular buildings in Turkey, "International Journal of Civil and Environmental Engineering 12.1 (2012): 42-48.

[7] Chopra, Anil K., and Rakesh K. Goel. "A modal pushover analysis procedure to estimate seismic demands for unsymmetric-plan buildings," Earthquake engineering and structural dynamics 33.8 (2004): 903-928.

[8] Mao, Jianmeng, Changhai Zhai, and Lili Xie. "An improved modal pushover analysis procedure for estimating seismic demands of structures," Earthquake engineering and engineering vibration 7.1 (2008): 25-31.

[9] Freeman, Sigmund A. "The capacity spectrum method as a tool for seismic design," Proceedings of the 11th European conference on earthquake engineering. 1998.