Voltage Stability Enhancement for Power Transmission System using Static VAR Compensator

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Abstract: This paper presents the potential applications of flexible AC transmission system (FACTS) controllers, such as the static VAR compensator (SVC), using the latest technology of power electronic switching devices in the fields of electric power transmission systems with controlling the voltage and power flow, and improving the voltage regulation. The SVC can be used to enhance voltage stability of the system with the possibility of adding additional damping control. With the application of SVC, the voltage stability can be improved under normal condition as well as under disturbances such as faults. A SVC performs such system improvements and benefits by controlling shunt reactive power sources, both capacitive and inductive, with high power electronic switching devices. This work is presented to solve the problems of poor dynamic performance and voltage regulation in an 230KV transmission system using SVC. To evaluate the voltage stability enhancement by SVC, the simulation model is implemented using Matlab/Simulink and performance analysis is done based on simulation results.

Keywords: Static VAR compensator (SVC), Thyristor controlled reactor (TCR), Voltage regulation, MATLAB Simulink, PI ontroller

1. INTRODUCTION

Power transmission system enhancements is very important for large scale system. The AC power transmission system has diverse limits, classified as static limits and dynamic limits. Traditionally, fixed or mechanically switched shunt and series capacitors, reactors and synchronous generators were being used to enhance same types of stability augmentation. For many reasons desired performance was being unable to achieve effectively. A static VAR compensator (SVC) is an electrical device for providing fast-acting reactive power compensation on high voltage transmission networks and it can contribute to improve the voltages profile in the transient state and therefore, it can improve the quality performances of the electric services. A SVC can be controlled externally by using properly designed different types of controllers which can improve voltage stability of a large scale power system. And also designed PI controller. The dynamic nature of the SVC lies in the use of Thyristor devices. Therefore, this paper presents Thyristor based SVC with PI controller to improve the performance of multi-machine power system. In this paper, voltage stability enhancement by SVC is presented. The case study is carried out for load variation as well as application of three phase fault. Comparison is expressed for simulation results for without SVC and with SVC conditions.

2. ENHANCEMENYOFVOLTAGESTABILITY

Transmission systems are part of the overall electrical power supply systems. Transmission system consists of conductors carried on steel towers linking generation stations to users through the distribution system. They deliver bulk power from power stations to the load centres and large industrial consumers beyond the economical service range of the regular primary distribution lines. Like many transmission systems in the world, transmission system is characterized by high technical and non-technical losses, overloading, voltage instability, radial lines having no redundancy, results of de-regularization of the electricity market and obsolete substation equipment.

Increase in population leads to increase in economic activities and hence increase in electrical energy demand, thereby causing burdens on existing transmission lines also to increase. This has caused the loading of the transmission lines beyond their design limits with consequent reduction in power quality.

A major consequence of overstretching transmission lines is voltage instability. Voltage instability is defined as the inability of a power system to maintain steady voltages at all buses in the system under normal operating conditions and after being subjected to a disturbance. Instability may result in the form of a progressive fall or rise of voltage of some buses. The possible outcome of voltage instability is loss of load in the area where voltages reach unacceptably low values or a loss of integrity of the power system. Voltage instability could be due to large disturbance or small disturbance.

The proximity of a given system to voltage instability is typically assessed by indices that measure one or a combination of:

- Sensitivity of load bus voltage to variations in active power of the load.
- Sensitivity of load bus voltage to variations in injected reactive power at the load bus.
- Sensitivity of the receiving end voltage to variations in sending end voltage.
- Sensitivity of the total reactive power generated by generators, synchronous condensers, and SVS to variations in load bus reactive power

There are various conventional methods of improving the voltage stability of power systems. Some of these are as follow.

2.1 Reactive Power Compensation

Reactive power compensation is an important issue in electric power systems being an effective measure to improve voltage stability. Reactive power must be compensated to guarantee an efficient delivery of active power to loads, thus releasing system capacity, reducing system losses, and improving system power factor and bus voltage profile. Through controlling the production, absorption, and flow of reactive power at all levels in the system, voltage/Var control can maintain the voltage profile within acceptable limit and reduce the transmission losses. Compensation could be shunt whereby the compensating device is connected in parallel with the circuit to be compensated. It can be capacitive (leading) or inductive (lagging) reactive power, although in most cases, compensation is capacitive. Shunt compensation is successful in reducing voltage drop and power loss problems in the network under steady load conditions as it reduces the current flow in areas of installation. It could also be series whereby the compensating device is connected in series with the circuit to be compensated. Whereas shunt compensation reduces the current flow in areas of installation, series compensation acts directly on the series reactance of the line. It reduces the transfer reactance between supply point and the load and thereby reduces the voltage drop.

2.2 Synchronous Condensers

Synchronous condenser is simply a synchronous machine without any load attached to it. Like generators, they can be over-exited or under-exited by varying their field current in order to generate or absorb reactive power. Synchronous condensers can continuously regulate reactive power to ensure steady transmission voltage, under varying load conditions. They are especially suited for emergency voltage control under loss of load, generation or transmission, because of their fast, short-time response. Synchronous condensers provide necessary reactive power even exceeding their rating for short duration, to arrest voltage collapse and to improve system stability.

2.3 Excitation Control

When the load on the supply system changes, the terminal voltage of the alternator also varies due to the changes in voltage drop in the synchronous reactance of the armature. Since the alternators have to be run at a constant speed, the induced emfs, therefore, cannot be controlled by adjustment of speed. The voltage of the alternator can be kept constant by changing the field current of the alternator in accordance with the load. The excitation control method is satisfactory only for relatively short transmission lines.

2.4 Tap-Changing Transformers

Tap-changing transformer method is a method of voltage control for long transmission lines where main transformer is necessary. The principle of regulating the secondary voltage is based on changing the number of turns on the primary or secondary i.e. on changing the ratio of transformation. Decrease in primary turns causes increase in emf per turn, and so in secondary output voltage. Secondary output voltage can also be increased by increasing secondary turns and keeping primary turns fixed. In other words, decrease in primary turns has the same effect as that of increase in secondary turns

2.5 Booster Transformer Sometimes

It is desired to control the voltage of a transmission line at a point far away from the main transformer. This can be conveniently achieved by the use of a booster transformer. The secondary of the booster transformer is connected in series with the line whose voltage is to be controlled. The primary of this transformer is supplied from a regulating transformer fitted with on-load tap-changing gear. The booster transformer is connected in such a way that its secondary injects a voltage in phase with the line

2.6 Phase-Shifting Transformers

When the load on the supply system changes, the terminal voltage of the alternator also varies due to the changes in voltage drop in the synchronous reactance of the armature. Since the alternators have to be run at a constant speed, the induced emfs, therefore, cannot be controlled by adjustment of speed. The voltage of the alternator can be kept constant by changing the field current of the alternator in accordance with the load. The excitation control method is satisfactory only for relatively short transmission lines

3. STATIC VAR COMPENSATOR

The Static Var Compensator (SVC) is a device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow on power grids. The SVC regulates voltage at its terminal by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (SVC capacitive). When system voltage is high, it absorbs reactive power (SVC inductive). The variation of reactive power is performed by switching three-phase capacitor banks and inductor bank connected on the secondary side of a coupling transformer. Each capacitor bank is switched on and off by three thyristor switches (Thyristor Switched Capacitor or TSC). Reactors are either switched on-off (Thyristor Switched Reactor or TSR) or phase-controlled (Thyristor Controlled Reactor or TCR). Figure shows a single-line diagram of a static var compensator and its contr system

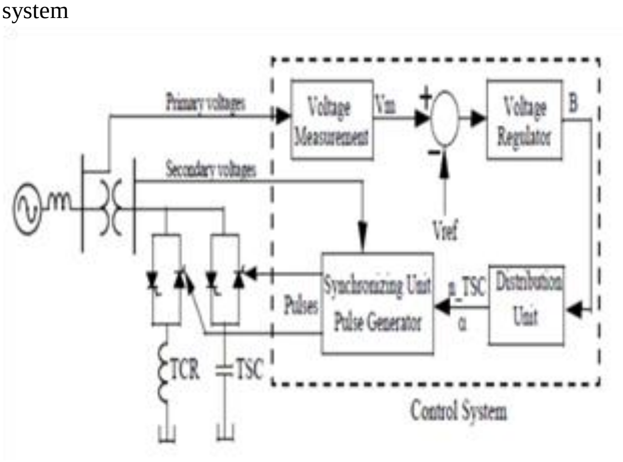

Figure 1. Single-line diagram of an SVC and its control system

The control system consists of: A measurement system measuring the positive-sequence voltage to be controlled. A voltage regulator that uses the voltage error (difference between the measured voltage Vm and the reference voltage Vref) to determine the SVC susceptance B needed to keep the system voltage constant. A distribution unit that determines the TSCs (and eventually TSRs)that must be switched in and out, and computes the firing angle α of TCRs. A synchronizing system and a pulse generator that send appropriate pulses to the thyristors

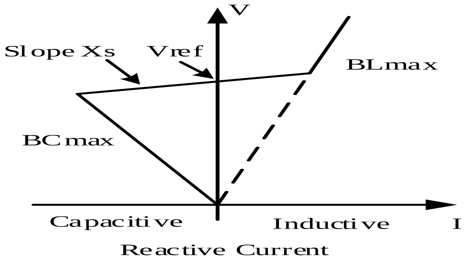

Figure.2. Steady State VI Characteristic of SVC

The SVC can be operated in two different modes: In voltage regulation mode (the voltage is regulated within limits) and In var control mode (the SVC susceptance is kept constant). When the SVC is operated in voltage regulation mode, it implements the following V-I characteristics. As long as the SVC susceptance B stays within the maximum and minimum susceptance values imposed by the total reactive power of capacitor banks (Bcmax) and reactor banks (Blmax), the voltage is regulated at the reference voltage Vref. However, a voltage drop is normally used (usually between 1% and 4% at maximum reactive power output).

4. MODELING OF HIGH VOLTAGE TRANSMISSION SYSTEM

For the voltage stability enhancement by SVC, the detail study is carried out at 230 kV Thanlyin Primary substation. It is located at southern Yangon, Myanmar. The single line diagram of the selected transmission system is shown in Figure 4. The important data for the system are described in Table 1 through Table 4.)

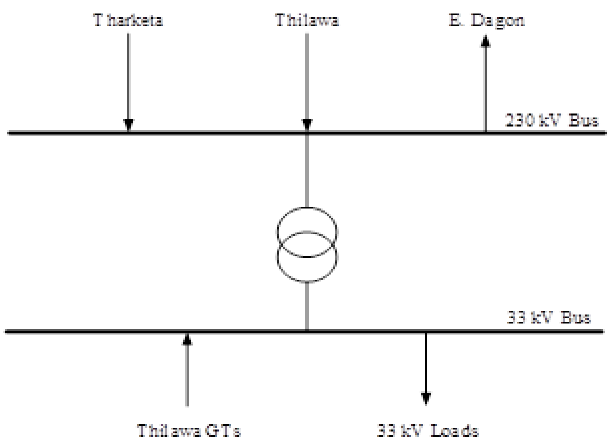

Figure.3. Single Line Diagram for Thanlyin Substation

Table 1. Source data of the system

Parameters	TKT	TLW 230	TLW GT
Phase-to-phase voltage (kV):	230	230	33
3-phase short-circuit level at base voltage (MVA):	3500	4000	2000
Base voltage (kV):	230	230	230
X/R ratio:	10.31	10	8
Generator type:	PV	Swing	PV
Active power generation P (MW)	32.6	-	37.0

Table 2. Load data of the system

Parameters	E. Dagon	33 kV
Nominal phase-to-phase voltage Vn (kV)	230	33
Active power P (MW):	102	27.3
Base voltage (kV):	230	33
Inductive reactive power QL (MVAR):	40.2	16.92

Table 3. Line data of the system

Winding 1 connection (ABC terminals)	Y
Winding 2 connection (abc terminals)	Y
Nominal power and frequency [Pn(VA) , fn(Hz)]	[100e6 50]
Winding 1 parameters [V1 Ph-Ph(Vrms) , R1(pu) , L1(pu)]	[230e3 0.013 0.13]
Winding 2 parameters [V2 Ph-Ph(Vrms) , R2(pu) , L2(pu)]	[33e3 0.013 0.13]
Magnetization resistance Rm (pu)	400
Magnetization inductance Lm (pu)	400

5. MODELING OF SYSTEM

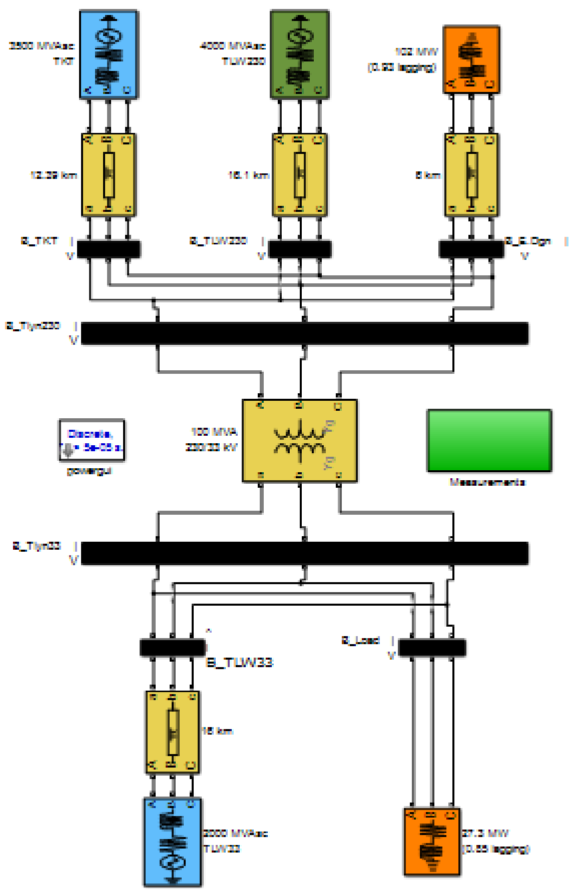

Figure 4. Simulink model of Thanlyin 230/33kV substation for Voltage Stability Study

For this study, the simulation model is implemented with Matlab software. The simulation model consists of 230 kV and 33 kV system. There are two loads, three sources, four feeders and a transformer. To study the simulation results, the voltages, currents and powers are measured at each load/source. For all the simulations, the simulation time is set as 1 second and sampling time is set as 50 µsecond. To observe the voltage stability conditions of the existing system, the simulations are carried out for maximum load condition and fault conditions the area where voltages reach unacceptably low values or a loss of integrity of the power system. Voltage instability could be due to large disturbance or small disturbance

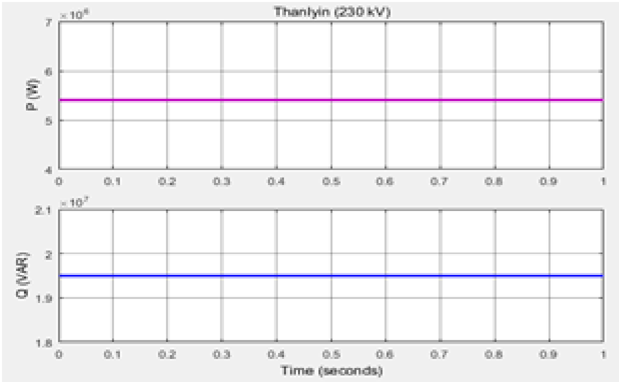

Figure 5. Active and Reactive Power at 230kV Buses under Maximum Load

The active and reactive powers under maximum load at 230kV bus and 33 kV bus are shown in Figure 6 and Figure 7 respectively. The values of the powers are nearly the same that are mentioned in the Tables. Fig. 8 shows voltages at 230/33 kV busses under maximum load. Under maximum load condition, the voltages are about 228 kV at 230 kV bus and about 31.2 kV at 33 kV bus. Fig. 9 shows voltages at 230/ 33kV busses under three phase fault. Under three phase fault condition, the voltages are about 213 kV at 230 kV bus and about 1.5 kV at 33 kV bus.

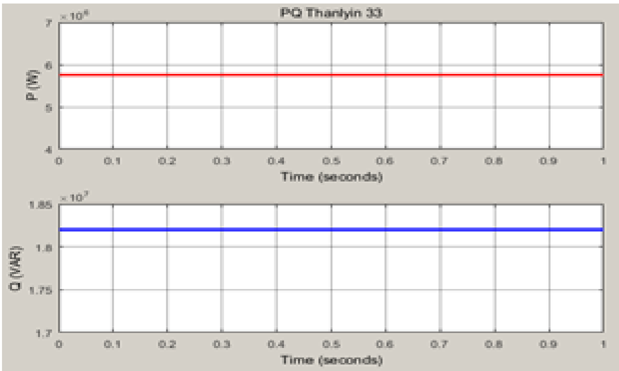

Figure 6. Active and Reactive Power at 33kV Buses under Maximum Load

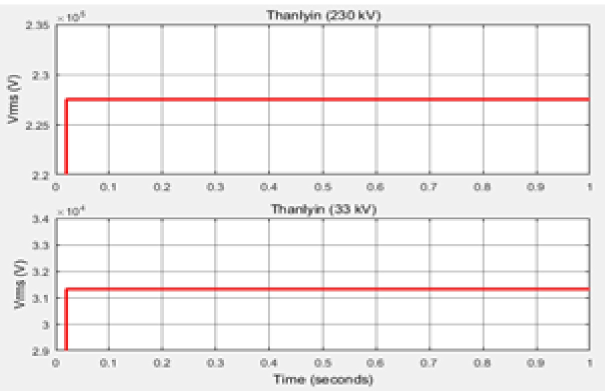

Figure.7. Voltages at 230/33 kV Busses under Maximum Load

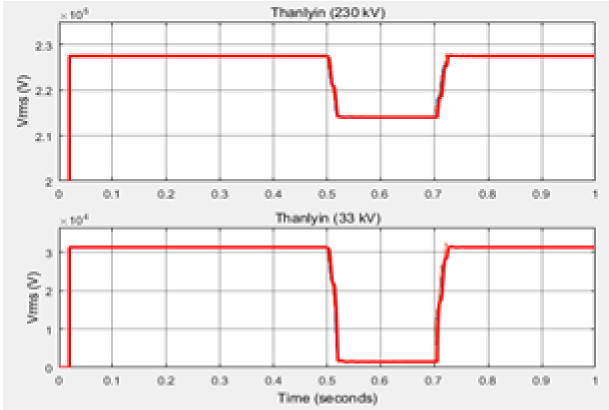

Figure.8. Voltage Stability Study at 230/ 33kV Busses (Under Three Phase Fault)

6. DESIGN CALCULATION OF TSC AND TCR

The compensated values for the capacitance and inductance are calculated based on the setting.

$$X_{SVC} = \frac{V_{bus}^2}{Q_{SVC}} = \frac{(230x10^3)^2}{21x10^6} = 2519\Omega$$

$$X_{SVC} = \frac{X_{TSC}\ X_{TCR}}{X_{TSC} + X_{TCR}},\ X_{TSC} = 3X_{TCR}$$

$$= \frac{3X_{TCR}\ X_{TCR}}{3X_{TCR} + X_{TCR}} = \frac{3X_{TCR}^2}{4X_{TCR}} = 0.75X_{TCR}$$

$$\therefore X_{SVC} = 0.75\ X_{TCR}$$

$$\therefore X_{TCR} = \frac{X_{SVC}}{0.75} = \frac{2519}{0.75} = 3358.73\Omega$$

$$\therefore X_{TSC} = 3 \text{ x } 3358.73 = 10076.19\Omega$$

$$X_{TCR} = 2\pi fL,\ f = 50 \text{ Hz},\ X_{TSC} = \frac{1}{2\pi fc}$$

$$L = \frac{X_{TCR}}{2\pi\pi} = \frac{3358.73}{2\pi \text{ x } 50} = 10.69H$$

$$C = \frac{1}{2\pi f X_{TSC}} = \frac{1}{2\pi\, 50 \text{ x } 10076.19} = 3.159x10^{-7} F$$

$$X_{TCR} = \frac{\pi X_L}{\sigma - \text{Sin}\sigma},\ \sigma = 2(\pi - \alpha) = 2(\pi - \frac{\pi}{2}) = \pi$$

X_L = reactance of the Linear inductor. α and σ are Thyristor conducting angle and firing angle.
At α =90, TCR conduct fully and its equivalent reactance X_{TCR} become X_L

$$X_L = \frac{X_{TCR}(\sigma - \sin\sigma)}{\pi}$$

$$X_L = \frac{3358.73(\pi - \sin(180^\circ))}{\pi}$$

$$X_L = 3358.73\Omega$$

7. VOLTAGE STABILITY ENHANCEMENT BY SVC

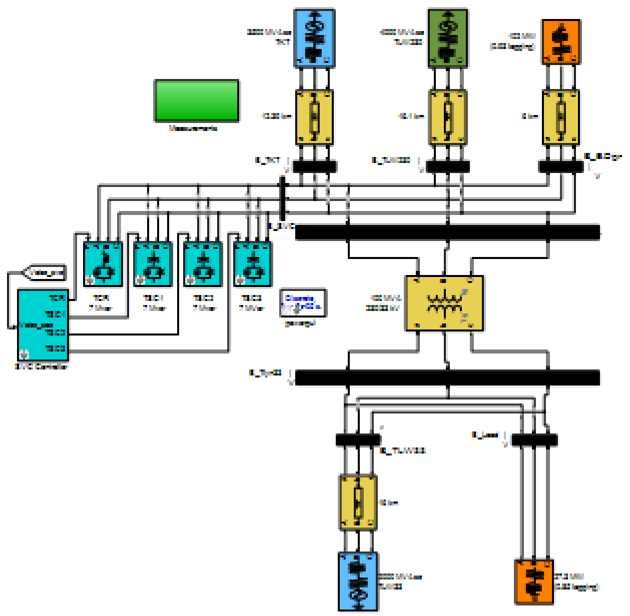

Figure.9. Simulink model of Thanlyin 230/33kV substation for Voltage Stability by SVC

In the simulation, the fault is located at 33 kV load side of transformer since most of faults are occurred at that location. To obtain the stable voltage of the complete system, SVC is located at 230 kV bus bar of Thanlyin substation. With this SVC location, the cost can be reduced and the voltage stability of the complete system can be better small disturbance.

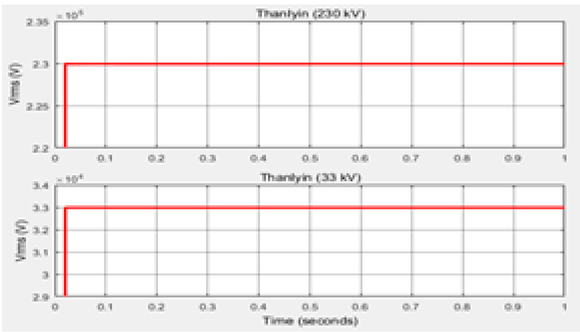

Figure.10. Voltage Stability by SVC at 230/33 buses

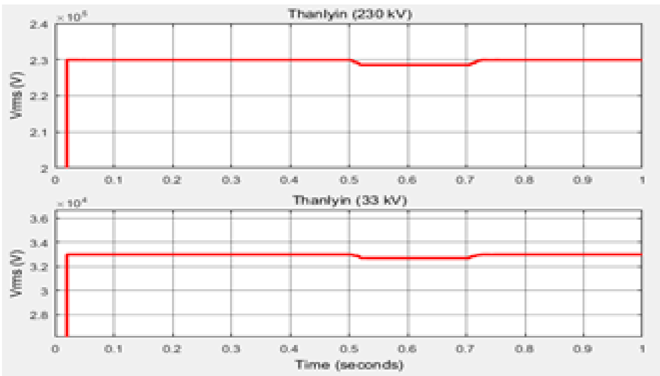

Figure.11.. Voltage Stability by SVC at 230/33 kV Buses (under Three Phase Fault)

For the simulation with fault, the total simulation time is set as 1 second. To avoid the starting transient effects, the fault is initiated at 0.5 second and cleared at 0.7 second. For three phase fault and without and with SVC simulations, the fault occurrence is the same as start at 0.5 second and end at 0.7 second. The following figures illustrate the voltages at 230 kV bus and 33 kV bus of Thanlyin substation.

Table 5. Voltage Comparison For Without And With SVC

Load Condition	230 kV Bus (kV)		33 kV Bus (kV)	
	without SVC	With SVC	without SVC	With SVC
Max Load	227.5	230.0	31.32	33.00
Fault	214.0	228.6	1.49	32.69

8. CONCLUSION

This paper has examined the concept of voltage stability and methods used to evaluate and extend the stability limits of a power system. The work has been focused on SVCs and how they could be used to stabilize the power system to avert a voltage collapse situation. Sensitivity indices have been presented and evaluated to identify areas in the Thanlyin Substation which is prone to super a voltage collapse under certain stressed conditions. In some cases, transmission SVCs also provides an environmentally-friendly alternative to the installation of costly and often unpopular new transmission lines. Dynamic performance and voltage control analysis will continue to be a very important process to identify system problems and demonstrate the effectiveness of possible solutions. Therefore, continual improvements of system modelling and device modelling will further ensure that proposed solutions are received by upper management with firm confidence..

9. ACKNOWLEDGMENTS

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Determination of the Seismic Performance of Concentrically Braced Steel Structures

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Abstract: Steel building systems are preferred lateral force resisting system in regions with high seismic risk due to their ductility capacity. Concentrically Braced Frames (CBF) are commonly used in steel structures provide one of the most economical solutions. Concentrically braced frames are widely used in steel structures as lateral load bearing system in the high level seismic zones.

In this study, it is aimed to perform a performance analysis according to the Turkish Building Earthquake Code 2018 in a five-story reinforced concrete shear wall-framed structure in Izmir where active fault lines are located. Steel structure was designed and also, the performance analysis of this structure was performed by using SAP 2000 computer software which has advanced analytical techniques. In the earthquake engineering, performance-based design method is used to determine the level of expected performance of the structures under the earthquake effect. Level of performance is related to the damage situation that could be occurred in the structure after the earthquake.

The selected structure has 6 storey and CBF's designed with respect to Turkish Building Earthquake Code-2018(TBEC-2018) and Steel Structure Code 2018 (SSC-2018). In addition, the structure is consisted of 4 bays in X direction and 3 bays in Y direction. Results show that for CBF steel structures expected performance level which is life safety has been provided.

Keywords: Concentrically braced steel structure; performance based design; TBEC-2018; Steel Structures Design Code 2018.

1. INTRODUCTION

It is important to design an economical and safe structure in earthquake zones. As a result of many earthquake, Turkey has been damaged as a result of many earthquakes. For this reason, it is closely related to the nonlinear behaviour and ductility of the structures that will be designed in earthquake zones under the effects of the earthquake. These steel structures increase their importance. Erdem (2015) [1] investigated non-linear performance analysis of existing and strengthened steel structures by X shaped bracing members with 3, 5 and 7 stories which have soft story irregularity is performed according to FEMA-356 and Turkish Earthquake Code-2007. Damage ratios of the structural members and global performance levels are determined as well as modal properties and story drift ratios after non-linear finite elements analysis for each structure. Speicher et al., (2016) [2] presented the results of a seismic performance assessment using ASCE 41-06 for six special concentrically braced frames (SCBFs) designed in accordance with the 2012 International Building Code. The correlation between ASCE 7-10 and ASCE 41-06 is investigated to compare the seismic performance anticipated by the two standards. Three archetype buildings (4-, 8-, and 16-story) with SCBFs along one principal direction are designed for seismic effects. Wijesundura et al., (2018) [3] evaluated the seismic performance of suspended zipper concentric braced frames designed according to Eurocode 8 and to compare their performance with conventional concentric braced configurations. In this studies, introduces a novel design methodology to size braces, zipper columns, beams and columns in suspended zipper frames. it can be concluded that the performance of suspended zipper frame is better than that of conventional concentrically braced frames in medium-rise buildings, but not in low-rise buildings.

Diagonal steel frames are horizontal load bearing systems consisting of frames using moment-transfer or moment-free beam-column connections, and diameters connected centrally and eccentrically. The horizontal load bearing capacities of such system are provided by the axial force of the elements, in addition to their bending strength. 4]Crossed steel frames are divided into two depending on the arrangement of the diagonal [4].

a) Concentric Steel Bracing (Figure 1)

b) Eccentric Steel Bracing (Figure 2)

Concentric steel bracings are designed as a system of high ductility level or a system of nominal ductility level. However, eccentric steel bracing should be designed as a system of high ductility level.

In the analysis of structural systems under earthquake effects, linear and nonlinear calculation methods can be used. According to the linear theory it is assumed that the materials is linear-elastic and the displacements are very small. In the nonlinear calculus, the behaviour of materials beyond the linear-elastic boundary is taken into account and the displacements are not very small.

Construction systems usually show linear behaviour under operating loads. Calculated displacements, deformations and stresses are accepted for linear theory. With external influences, the deformation and linear-elastic limit is exceeded when the operating load limit is exceeded and the

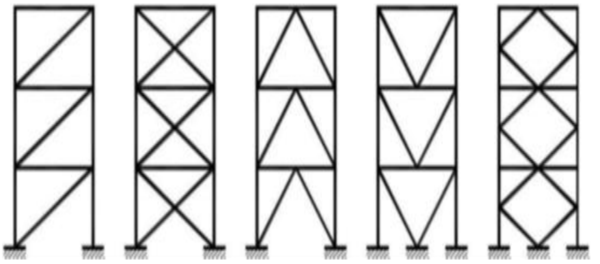

Figure 1. Concentric Steel Bracings

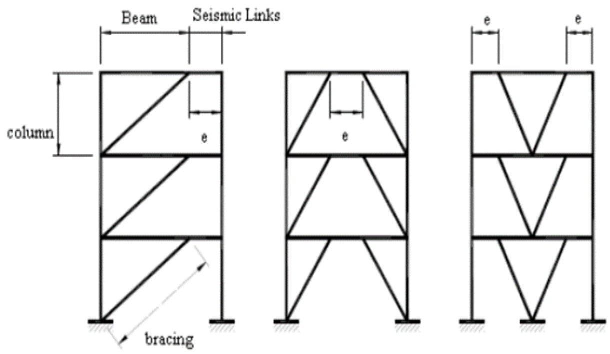

Figure 2. Eccentric steel bracing

carrying power is approached. In this case, displacements taken are not too small. In this case the linear theory is not valid. The non-linear theory will apply considering the behavior beyond the linear elastic boundary.

Non-linear pushover analysis is a special analysis method used in the performance-based design of structures under seismic effect. In the pushover analysis method, the capacity curve showing the relationship between the base shear force of the structure and the top displacement volition is obtained. This curve expresses the behaviour of the structure under the influence of increased base shear force. In order to achieve the projected performance target, the capacity must meet the required volition. Under the effect of the increased base shear force, changes in the slope of the force-displacement curve are absorbed with the starting capacity elements of the horizontal carrier system exceeding the yield limit values of these elements.

In this study, horizontal load bearing system is examined by using linear and nonlinear calculation methods which are determined in the earthquake regulations of the system chosen as the central Concentric Bracing with high ductility level. For this purpose, the building's design Steel Structures Code-2018 (SSC-2018) [4] and restored Turkish Earthquake Code-2018 (TEC-2018) [5] were used.

The aim of this study is to show linear and non-linear behaviors under the effect of horizontal load of steel structures using different stiffness element. In this study, using the SAP 2000 program [6], 3 different models with 4 storeys with 5 spans in X direction and 3 spans in Y direction were modeled in SAP 2000 program. Equivalent Seismic Load Method and Pushover Analysis were applied. As a result of these analyses, the mode shapes, period and displacement values of the obtained structures and the cross-sectional effects of each analysis were examined and the comparisons were made. Based on these results it is compared models and decided on the ideal bracing-sections model.

2. METHODS

In this study, steel structures consisting of 6-storeys with 4 spans in X directions and 3 span in Y directions were performed according to the equivalent earthquake load method and static pushover analysis. Moment Resisting Frame (Model 1) is added to this building model in the X direction by rigid bracing members and X bracing (Model 2) and Reverse V bracing (Model 3) building models are taken into consideration. SAP 2000 package program was used for modelling steel structure types. Equivalent Earthquake Load method and Single Mode Pushover analysis were used in earthquake analysis of three different steel structure models. Periods, displacements and internal forces are obtained as a result of the analyses are compared with each other for three different models with the help of tables and figures. The structure is in İzmir province Bayraklı district Latitude: 38.4813360, Longitude: 27.1259430. Spectral acceleration coefficients are Ss=1.088, S1=0.266. Ground class is ZC and building coefficients of importance at the level of DD-2 earthquake ground motion is selected as I=1. Ground floor is 3.50 m in height and normal floors are 3.0 m in height. In the moment resisting frame, the columns are selected as HE450B, X directions beams are IPE270, Y directions beams are IPE400/IPE360, secondary beams are selected as IPE 270 profile in X directions. X bracing structure, the columns are selected as HE450B, X directions beams are IPE240, Y directions beams are IPE300, secondary beams are selected as IPE 270 profile in X directions, bracing-members are box 120/120/10 profile. In reverse V bracing structure, the columns HE450B, X directions beams are IPE240, Y directions beams are IPE300, secondary beams are IPE270 in the X directions, bracing-members are box 100/100/10 profile directions.

In Figure 3 the floor plan of the steel Moment Resisting Frame model (Model 1) examined is given.

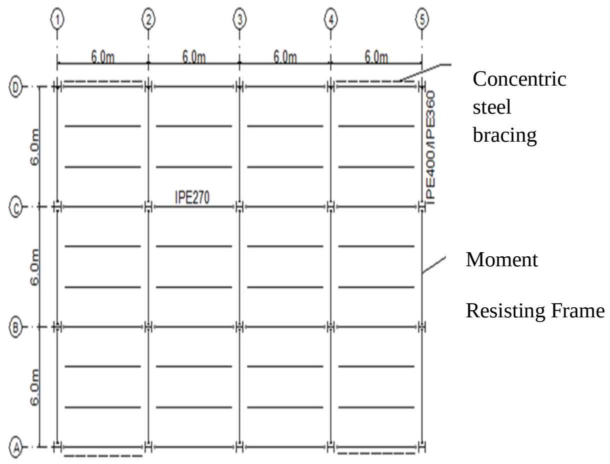

Figure 3. Typical floor plan of the steel structures

Figure 4-6 shows the 3D finite element model prepared in SAP 2000 of the building models taken into account in the study.

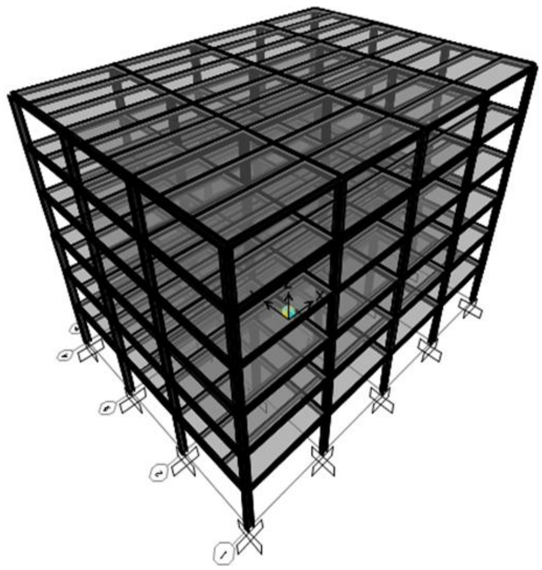

Figure 4. Model 1 3D Finite Element Model

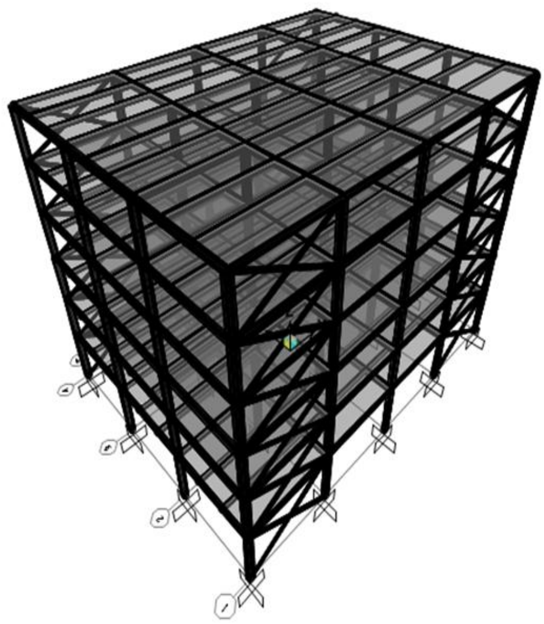

Figure 5. Model 2 3D Finite Element Model

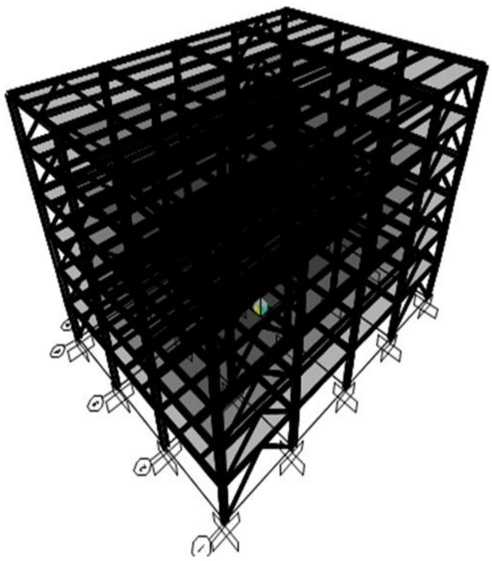

Figure 6. Model 3 3D Finite Element Model

2.1. The Equivalent Earthquake Load Method

According to TEC-2018, for each structure linear analysis were performed under earthquake force by using equivalent earthquake load.

The vertical loads used in the structural calculations are accepted as follows (TS 498) [7]

a) Roofing: Total dead load 4.8 kN /m^2

Live load 1.5 kN/m^2

Parapet wall load 1.0 kN/m

b) Normal Floor upholstery: Total dead load 4.8 kN /m^2

Live load 2.0 kN /m^2

Stair load 3.5 kN /m^2

External wall load 3.0 kN/m^2

Snow load value is taken from TS 498 load standard. TBDY (2019), 30% of the snow loads will be taken into account in the calculation of the weight of the roof. Snow load value is calculated as 0.6kN/m2.

Equivalent Seismic Load Analysis and Static Pushover Analysis were designed in SAP 2000 program and analysis are done according to AISC360-10 [8] and result were obtained.

Static analysis results are given under the effect of earthquake, model of Moment Resisting Frame (Model 1), X bracing (Model 2) and reverse V bracing (Model 3) which ae formed with SAP 2000 program. As a result of the analysis, the period, displacement values 1.2G+Q+Qr+0.2S+EY12+0.3EZ and 1.2G+Q+Qr+0.2S+EY12+0.3EZ_NL loadings of the bracing –sectional impact values of the tables and figures with the help of three different models are given for each other. In the these combinations, G1,G2 is the dead loads consisting of the constant load floor and wall respectively,

Q, Qr is the live loads consisting of normal story and roof story moving loads, respectively S is the snow load, Ex, Ey, Ez is the earthquake loads in the X, Y and Z directions respectively. Ez_NL is the influence of design basis earthquake in the direction of the non-linear effect of earthquakes.

The period and displacement values of the Moment Resisting Frame (Model 1), X Bracing (Model 2) and Reverse V Bracing (Model 3) models for the node indicated in Figure 7 are given in Figure 8-9. The displacement in the effect of earthquake loads according to the section given in Figure 7 are given in the graphs. As can be seen in the graphs, in Model 1 the largest period and displacement values were obtained.

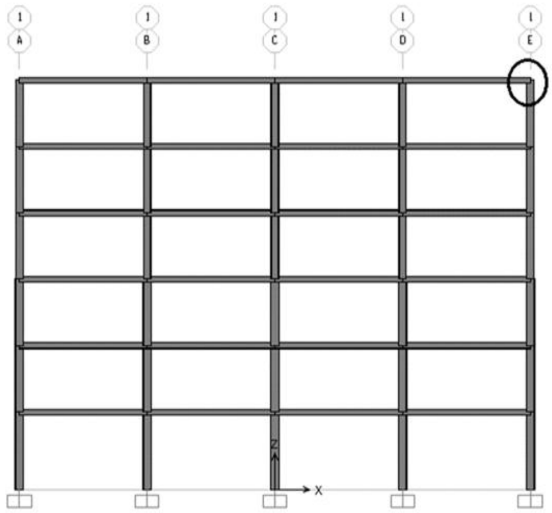

Figure 7. The joint nodes at which the displacement values are examined

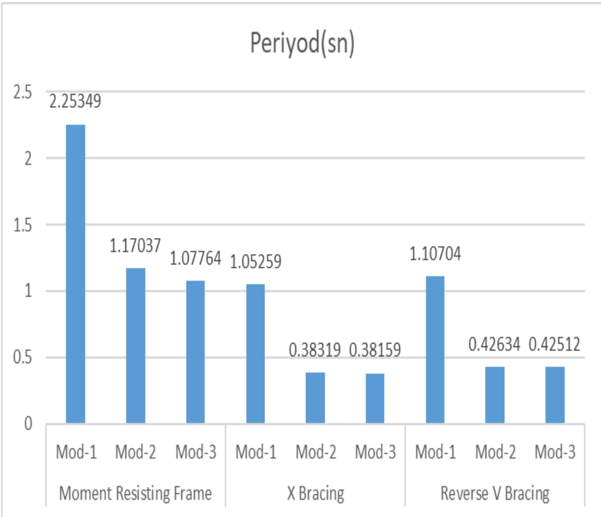

Figure 8. Period values of the examined building models

Figure 8 shows the values of the models analysis results and periods of the Moment Resisting Frame (Model 1) X Bracing (Model 2) and Reverse V Bracing (Model 3) models. As can be seen from the table, the largest period values are obtained in Model 1. It was found that there was a 46.7 % decrease in period values with the use of rigid elements in the structure. Figure 9 shows the values of the displacements. In this figure, Ex and Ey are earthquake effects X and Y directions, respectively.

As seen in Figure 9, the largest displacement value was obtained in Model 1 under earthquake effect in the X direction.

The axial forces, shear forces and bending moments values of the Moment Resisting Frame (Model 1), X Bracing (Model 2) and Reverse V Bracing (Model 3) models for the beam and column indicated in Figure 10 are given in Table 1-2. The internal forces in the effect of earthquake load combinations,

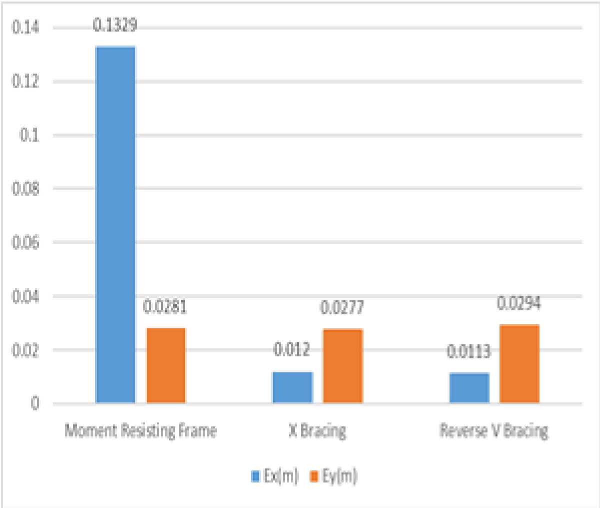

Figure 9. Displacement values of examined building models

(1.2G + Q + Qr + 0.2S + EY12 + 0.3EZ and 1.2G + Q + Qr + 0.2S + EY12 + 0.3EZ) according to the sections given in Figure 10 are given in the Tables 1-2. As can be seen in the tables, it is seen that the bending moment values in the Model 1 are higher than the models using rigid element.

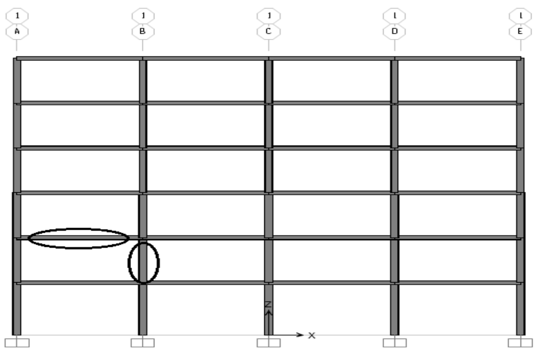

Figure 10. The beam and column at which the internal forces are examined

When the internal forces given are examined, it is seen that the bending moment values in the Moment Resisting Frame (Model 1) model are higher than the models using rigid element. The bracing members types used in this study increase the axial forces from load combination and decrease the bending moment of the steel structures.

2.2. The Pushover Analysis Method

Pushover analysis method is applied to determine the strength and deformation capacity of a structure under earthquake effects. The plastic hinge places are assumed and defined on the two ends of the column and beams elements constituting the bearing system. Nonlinear static analysis was performed for Model 1-3 in the X and Y directions. It is seen from Figures 11,12,13 that static pushover curvatures are obtained by analysing bearing system under the vertical loads and proportional incremental interval seismic loads for Model 1-3.

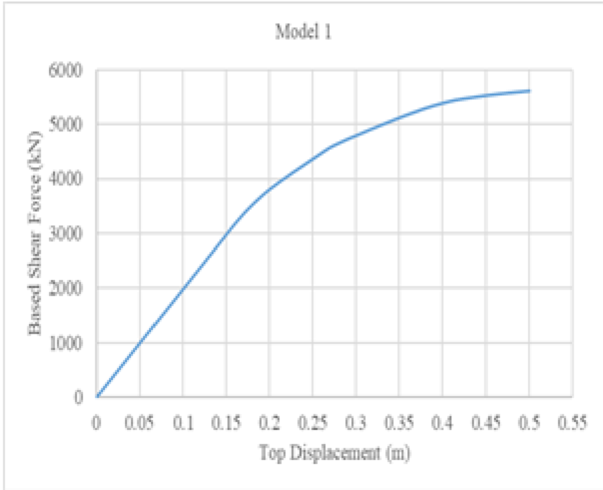

Figure 11. Capacity curves for Y direction by pushover analysis for Model 1.

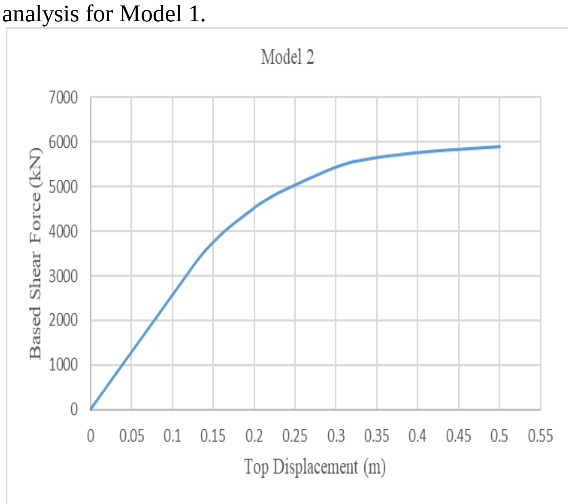

Figure 12. Capacity curves for Y direction by pushover analysis for Model 2.

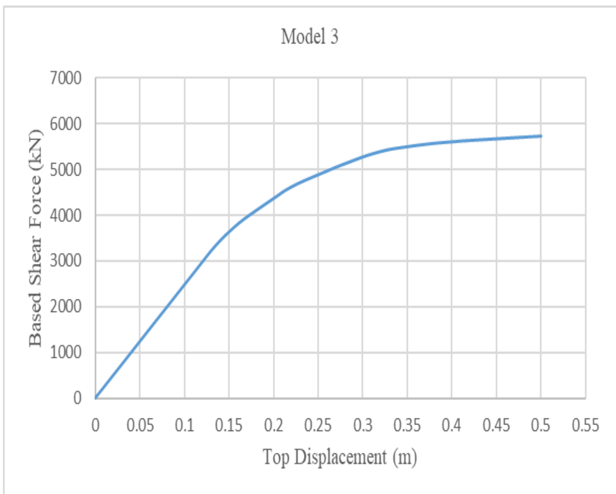

Figure 13. Capacity curves for Y direction by pushover analysis for Model 3.

The base shear forces and top displacements at the performance paint by the static pushover analysis are show in Table 1-2.

Table 1. X Base shear force and top displacement values

Models	**Base shear force (kN)**	**Top displacement (m)**
Model 1	2154.61	0.512
Model 2	8709.67	0.182
Model 3	2577.59	0.098

Table 2. +Y Base shear force and top displacement values

Models	**Base shear force (kN)**	**Top displacement (m)**
Model 1	5605.87	0.52
Model 2	5901.18	0.51
Model 3	5746.14	0.51

As can be seen from Table 1-2, the peak displacement in the three different models were observed close to each other. On the other hand, the base shear force values at the performance point are the largest in the X- bracing system and the smallest value in the Moment Resisting Frames. This exhibit shows that more rigid behavior of the X-bracing system.

3. CONCLUSIONS

In this study, analysis was performed according to the Equivalent Seismic Load method and nonlinear static analysis (pushover analyses) of a steel structure consisting of 6-storey X directions 4 spans, Y directions 3 spans. Then, the rigid elements were added to the Moment Resisting Frame (Model 1) building model in the X direction differently. X Bracing (Model 2) and Reverse V Bracing (Model 3) building models were considered. As a result of the analyzes, the period, displacement, internal forces and plastic hinge points were compared with each other for three different models with the help of figures and tables. After examining the data obtained in the study, the following conclusions are reached.

As can be seen in the steel structures examined, it has been observed that there has been a significant decrease in the period, displacement and bracing-section effects of the models using the X bracing members in steel structures. It has been observed that the bracing members against horizontal loads increase the strength and stiffness. Model 2 showed a more rigid behavior compared to the other models. The rigid bracing members used in the elements provide this.

In the Y direction, the pushover analysis results close to the peak displacement values. However, the base shear force is the highest in Model 2. It shows that Model 2 will be more rigid against horizontal force. When looking at the number of plastic hinges, it is possible to obtain similar values in crossed systems, whereas in the system consisting of frames more plastic sections are obtained. This difference can be explained by the high degree of hyper statics in the system consisting of frames.

As a result of the + X direction pushover analysis, the base shear force value is the largest of the Model 2 system. This shows that the Model 2 system behaves rigidly. Model 1 has the largest displacement value in the system. This shows that the Model 1 system behaves ductile.

The bracing members types used in this study increase the axial forces from load combination and decrease the bending moment of the steel structures. In this case, it results with the yielding of columns under compression if not carefully designed.

On the other hand, the base shear force values at the performance point are the largest in the X- bracing system and the smallest value in the Moment Resisting Frames. This exhibit shows that more rigid behavior of the X-bracing system.

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Investigation of the Earthquake Performance of a Reinforced Concrete Shear Wall Hotel Using Nonlinear Methods

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Abstract: In the earthquake engineering, performance-based design method is used to determine the level of expected performance of the structures under the earthquake effect. Level of performance is related to the damage situation that could be occurred in the structure after the earthquake. In the performance-based structural design, it is predicted that more than one damage levels are emerged under one certain earthquake effect.

In this study, the seismic behavior of reinforced concrete shear wall hotel building collapsed during Van Earthquake, 2011, is investigated by the nonlinear static analysis. The selected reinforced concrete shear wall structure is located in Van, Turkey. The Turkish Building Earthquake Code in 2019 is considered for the assessing seismic performance evaluation of the selected reinforced concrete shear wall building. The performance goals of the reinforced concrete shear wall structure is evaluated by applying the pushover (Incremental Equivalent Earthquake Load Method) and procedures of the Code and nonlinear dynamic analysis. According to the code, the reinforced concrete shear wall hotel building is not expected to satisfy life safety performance levels. In this study, it is selected one collapsed building, because, it is tested reliability and usability of performance analysis method under design earthquake.
Keywords: Reinforced concrete shear wall structure, pushover analysis, nonlinear time history analysis, performance analysis, existing buildings.

1. INTRODUCTION

In Turkey, there are a large number of reinforced concrete building at the border and under the border of the earthquake safety. In addition, a large number of existing reinforced concrete shear wall building in first-degree seismic zone are needed seismic evaluation because noncompliance with the old code requirements, updating of codes, design practice of the building. The maintain and reinforcement of them is not possible respect of economic and technical reasons. Existing buildings earthquake safety evaluation of a more realistic form has been come in question. In the Turkish Building Earthquake Code in 2019 (TBEC-2019) [1], performance-based evaluations were to the fore by using advanced knowledge of earthquake engineering. Therefore, performance based design procedures have been investigated for the structures recently. There are several procedures for performance assessment in the literature. The most common assessment procedures are explained in four main guidelines/codes which are Applied Technology Council (ATC-40) [2], Federal Emergency Management Agency (FEMA 356) [3], FEMA440 [4] and TBEC-2019. TBEC-2019 came into use in 2007. Nonlinear dynamic analysis (NDA) is the most faithful analysis methodology between the all nonlinear analysis methods. However, static pushover analysis is happen significant due to its simple exercise check against to time history nonlinear analysis. Many articles have been published on performance evaluation of existing reinforced concrete buildings. The predominant building type which is mid-rise non-ductile reinforced concrete frames with hollow clay tile infill, thousands of which collapsed in a 'pancake' mode. The static pushover analysis may be less accurate for structures in which the story shear force vs. story drift relationships are sensitive to the applied load [6-7]. Another important point is that chapter 7 of TBEC-2019 entitled "Assessment and Strengthening of Existing Buildings" sets standards for performance assessment and rehabilitation of existing buildings [8]. Different procedures were developed the seismic deformation demands of multistory steel and concrete moment frames using nonlinear procedures based on spread hinge assumption [9].

There are many studies related to the performance analyses. These studies evaluated seismic performance of existing low and mid-rise reinforced concrete buildings by comparing their displacement capacities and displacement demands under selected ground motions experienced in the world [10-14].

In this paper, the pushover and time history nonlinear analysis are applied to forecast the expected earthquake performance of a reinforced concrete shear wall hotel building collapsed during Van (2011) earthquake, Turkey. The building is typical beam-column RC frame buildings with shear walls. The pushover and time history nonlinear analysis are realized by using the finite element Structural Analysis program SAP 2000 [15]. Beam and column components are modeled as nonlinear frame components with pileous plasticity by describing plastic hinges at both ends of beams and columns. Earthquake performance appreciate is realized in respect of the recently published TBEC-2019 that has likeness with FEMA-356 guidelines.

2. PERFORMANCE LEVELS

In general, three factors are considered in the performance-based design approach. These are capacity, volition and performance. Capacity can be considered as a whole of elements; the structure of the building, type of material, section geometry etc. Under the influence of external forces such as earthquakes, without any reduction in their carrying capacities, the ability to deform (ductility) and to remain stable against loads (stiffness) are generally defined as capacity. Demand can be defined as displacement and sectional effects that the movements formed during the Earthquake are desired to be met from the structure. Performance is related to the extent to which the capacity of the structure can meet the movements occurring during the Earthquake.

Performance Levels of Buildings to be Designed Under the Effect of Earthquake:

a) Uninterrupted Use Performance Level (UU); it is the building performance level where structural damage does not occur in building system elements or the damage is negligible.

b) Limited Damage Performance Level (LD); the building corresponds to the level of damage to the structural system elements, whereby a limited degree of damage or non-linear behavior occurs.

c) Controlled Damage Performance level (CD); in order to ensure life safety, the building bearing system corresponds to the level of controlled damage which is not very heavy.

d) Migration Prevention Performance Level; the building corresponds to the to the pre-cash situation where severe damage to the structural system elements occurs. Partial or complete migration of the building was prevented

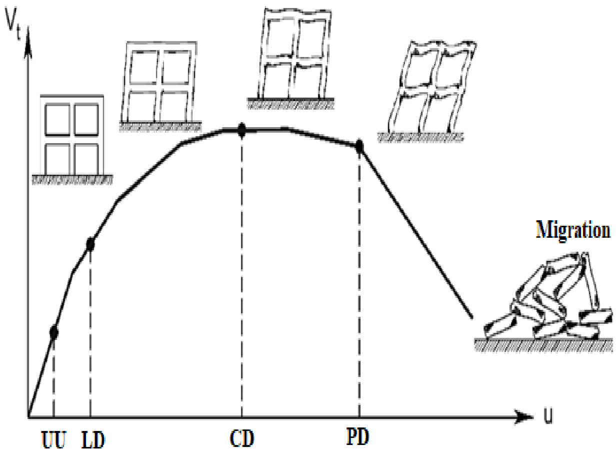


Fig.1. Building performance levels according to TBEC-2019

The definition of user-defined hinge properties requires moment-curvature analysis of each element. Mander model [16] for unconfined and confined concrete and typical steel stress-strain model with strain hardening for steel are implemented in moment-curvature analyses. The points B and C in Fig. 1 are related to yield and ultimate curvatures. The point B is obtained from SAP2000 using approximate component initial effective stiffness values as per TBEC-2019.

Moment-curvature analyses are carried out considering section properties and a constant axial load on the structural element. After the appropriate material properties are determined, structural element sections are modeled via XTRACT (2004) program [17]. In the section, two concrete models, confined and unconfined concretes, are used. The modeling is finished by inputting reinforced steels into defined section geometry. Thus, moment-curvature relations are determined after analyses.

Plastic hinge length is used to obtain ultimate rotation values from the ultimate curvatures. The plastic hinge length definition given in Eq. (1) is used:

$$Lp=0,08L+6fydb/40\geq 0,3fydb \quad (1)$$

In Eq. (1), Lp is the plastic hinge length, L is the distance from plastic hinge location to location of contraflexure, fy is yield stress longitudinal bar and db is the diameter of longitudinal reinforcement, respectively.

3. DESCRIPTION OF INVESTIGATED REINFORCED CONCRETE SHEAR WALL STRUCTURE

The building is typical beam-column reinforced concrete frame buildings with shear walls. A typical floor plan is shown in Fig. 2. Column dimensions in a story are 30x60, 25x60, 20x75 cm (Fig.2). The column dimensions in a defined position in the plan are the same in the other stories of the building. Longitudinal rebars are 8Ø14 for all columns. The longitudinal reinforcement ratio of these columns varies between 1.1% and 1.5%. The dimensions of all the beams in the building are the same as 25x60 cm. Beam longitudinal rebars are 3Ø14 on top and 5Ø14 in bottom for the residential building. Transverse rebars are Ø8/120 cm for columns and beams (Fig. 3). The reinforced concrete shear wall hotel building has 8 stories, stories first are 3.0 m and second stories are 3.5 m in height and other stories are 2.90 m (Fig.4). Framing of the building is irregular in plan where there are 4 axes in X-direction and 2 axes in Y-direction. Floor plan is not same for each story and first and second stories has an area of 87.65 m2 and other stories has an area of 115.92 m2. Slab thicknesses are 15 cm. For the buildings where the slabs act as rigid diaphragms on the horizontal axis, two horizontal translocations per floor and independence levels for the rotations around the horizontal axis will be considered. Independence levels of the floors will be defined for the center of mass of each floor and additional eccentricity will not be applied. The dead load is G =1.471 kN/m2 for all the floors except the top floor where the dead load was considered as G = 3 kN/m2. The live load is Q= 4.9 kN/m2 for each floor except the top floor where the live load was considered as zero. The structure is thought to be a hotel and its coefficient of live load addition is taken as n = 0.3.

Flexural rigidity is calculated for each member. Beams, columns and shear walls were modeled as frame elements which were connected to each other at the joints. Since the majority of buildings in Van, Turkey were constructed according to TEC-1975 [18], the selected building was designed according to this code, too. Because all the static projects are available, the reinforced-concrete properties of structural members are assumed to be known completely.

The pushover analysis is performed by using the finite element method Structural Analysis Program-2000 (SAP2000) [15]. Beam and column elements are modeled as nonlinear frame elements with lumped plasticity by defining plastic hinges at both ends of beams and columns. SAP2000 provides default or the user defined hinge properties options to model nonlinear behavior of components. In this study, user-defined hinge properties are implemented. Seismic performance evaluation is carried out in accordance with the recently published TBEC-2019 that has similarities with FEMA-356 guidelines.

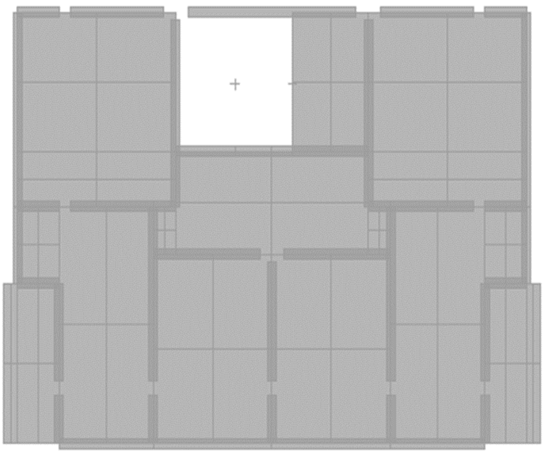
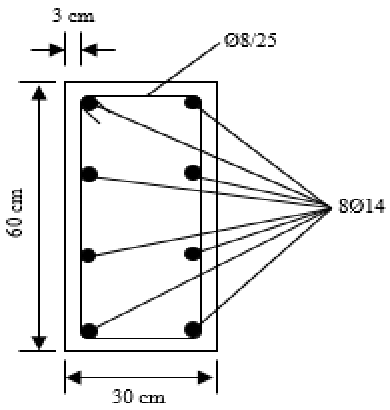
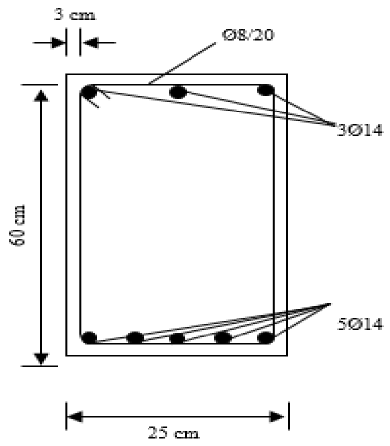


Fig. 2. Typical floor plan of the building.



a) 60x30 cm column



b) 60x25 cm beam

Fig. 3. Typical (a) beam and (b) column sections of building model.

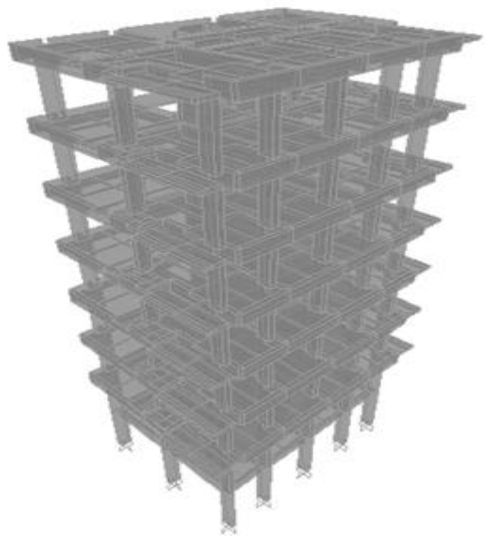
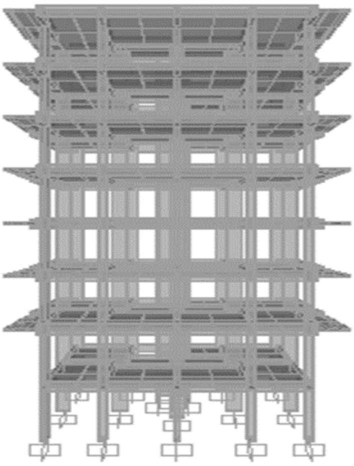
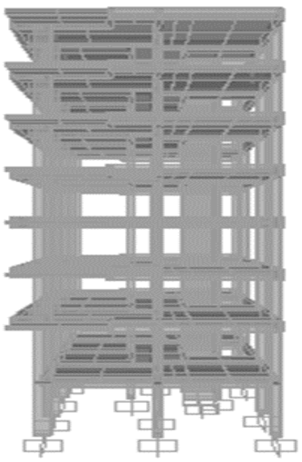


Figure. 4. 3-D finite element model of the reinforced concrete shear wall building



(a)



(b)

Fig. 5. (a) Typical X-Z sectional view (b) Typical Y-Z sectional view

The structure is in Van and in first-degree seismic zone. A design ground acceleration of 0.4g and soil class ZC that are similar to class C soil of FEMA-356 is considered in the analyses. The projected concrete class is C16 and projected reinforcing steel class is S420. The Young Modulus of concrete is 32000 MPa and reinforced steel is 205000 MPa. A reinforced concrete shear wall hotel building was analyzed in detail by performing pushover and nonlinear time history analyses according to the TBEC-2019. Three dimensional finite element model of the health building was prepared in SAP2000 structural analysis program shown in Fig. 4-5.

3.1.1. Performance Evaluation with Nonlinear Pushover Analysis

The aim of the nonlinear pushover analysis methods to be used for determining the structural performances of the buildings under seismic effect and for the strengthening analyses is enabling the measurement of the plastic deformation volitions regarding the ductile behavior and internal force volitions concerning the brittle behavior for a given earthquake. Afterwards, the magnitudes of the mentioned volitions are compared with the deformation and internal force capacities that are defined in TBEC-2019 and structural performance evaluation shall be conducted both at sectional and building level. According to TBEC-2019, to be able to use the pushover analysis, the number of floors of the building excluding the basement should not be above 8 and the torsional irregularity coefficient (η_{bi}) that is calculated in accordance with the elastic linear behavior without considering additional eccentricity should meet the condition $\eta_{bi} < 1.4$ for each floors. The torsional irregularity of the building is provided.

The building provides all these conditions, the nonlinear pushover analysis is utilized. Before incremental pushover analyses, a static analysis is done by taking into consideration vertical loads that is harmonic with the masses. This analysis is force controlled and the results of this study are assumed as initial conditions of incremental pushover analyses. The vertical loads in nonlinear static pushover analyses are assumed as follows:

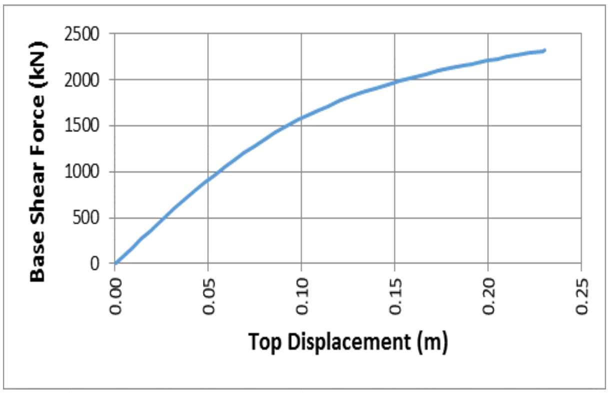
Vertical Load Combination (TBEC,2019)

$$G + nQ = G + 0.3Q \tag{2}$$

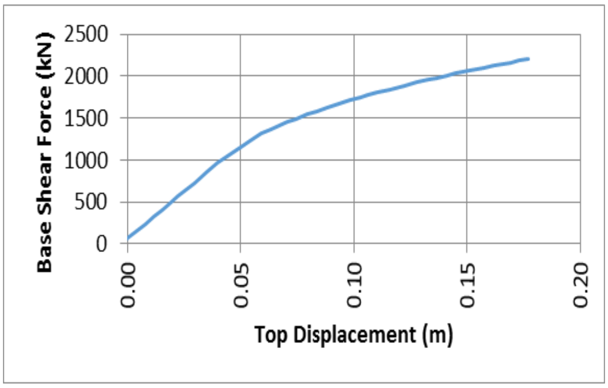
In Eq. (2), G is total dead load, n is the live load participation factor, Q is total live load stories of building, respectively.

The plastic hinge places are assumed and defined on the two ends of the column and beams elements constituting the bearing system. Plastic hinge length is assumed to be half of the section depth of elements as recommended in TEC (2007). It is seen from Fig. 6 that static pushover curvature is obtained by analyzing bearing system under the vertical loads and proportional incremental interval seismic loads for soil class Z3. Design earthquake is converted to spectrum curve and modal displacement demand is determined and performance points are determined by TBEC-2019 as seen in Fig. 7a-b. The plastic hinges are obtained by pushing again the bearing system up to this demand. It is seen in Fig. 7a-b that, in case

the incremental repulsion analysis is conducted via applying the Incremental Equivalence Seismic Load Method, the “modal capacity diagram” belonging to the primary (dominant) mode the coordinates of which are defined as “modal translocation – modal acceleration” shall be derived. The modal translocation volition belonging to the primary (dominant) mode shall be set taking the elastic behaviors spectrum and the modifications applied on this spectrum for different exceeding probabilities together with the mentioned diagram into consideration. In the final step, the translocation, plastic deformation (plastic rotation) and inner force volitions that corresponds to the modal translocation volition shall be calculated.



(a)



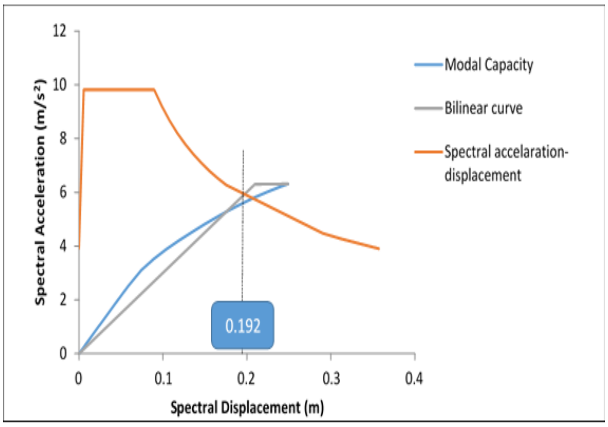
(b)

Fig. 6. Capacity curves for X direction (a) and Y direction (b) by pushover analysis for 8-story buildings.

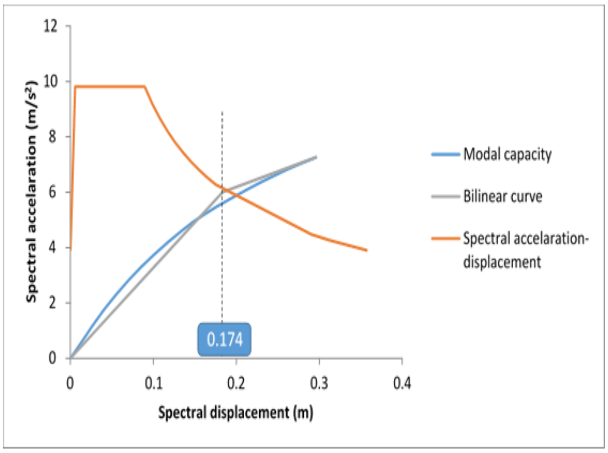
The pushover analysis of the selected structure is actualized under design earthquake (10% in 50-year hazard level) as proposed in the TBEC-2019. Nonlinear static pushover analyses are determined by SAP2000. A design performance level is a statement of the desired structural behavior of a building. After determination of damage regions of sections, the performance level of the building is controlled. It is seen from Fig.8 that the hinges through the structure after pushover analysis is under design earthquake (10% in 50-year hazard level).

According to TBEC-2019, the buildings that satisfy the conditions mentioned below can be agreed to be in Life Safety (LS) performance level provided that the brittle damaged components, if any, are strengthened:

(a) As the result of the calculations made for each earthquake direction applies on each floor, at most 30% of the beams except for the secondary ones (that does not take place in the horizontal load-bearing system) and at most the proportion of the columns defined in "paragraph b" can exceed the Advanced Damage Zone.



(a)



(b)

Fig. 7. Spectral acceleration, spectral displacement and Modal Capacity curves for X (a) and Y direction (b).

(b) The total contribution of the columns in the Advanced Damage Zone to the shear force that is borne by the columns in each floor should not exceed 20%. For the top floor, the ratio of the total shear forces of the columns in the Advanced Damage Zone to the total shear forces of all the columns at that floor can be at most 40%.

The performance levels, MN, GV, and GÇ are considered as specified in this code and several other international guidelines such as FEMA-356 and ATC-40 (Fig. 1). Displacement volition estimates for earthquakes with probability of exceedance of 10% in 50 years are compared for MN, GV and GÇ displacement capacities. For any floor, if these ratios not exceed targeted performance level's ratio, it is concluded that the building is sufficient for MN under design earthquake.

It can be seen from the result under soil class Z3 design earthquake of the pushover analysis through the X and Y direction (Fig.7a-b) that building does not collapse before reaching the push target. The maximum base shear force and maximum displacement in X−direction and the maximum base shear force and maximum displacement in Y−direction obtained from the pushover analysis of Z3 design earthquake are 2320 kN, 0.23 m, 2203 kN and 0.17 m, respectively. It is concluded from nonlinear static pushover analysis under design earthquake that according to displacement target of the building, the building provided LS rating in the view of LS level targeted in TBEC-2019. According to TBEC-2019, the reinforced concrete shear wall building is expected to satisfy LS performance levels under design earthquake. In each floor, the ratio of the beams provided targeted performance level to total beam number in this floor and the ratio of the shearing forces of the columns provided targeted performance level to total floor shear force are determined.

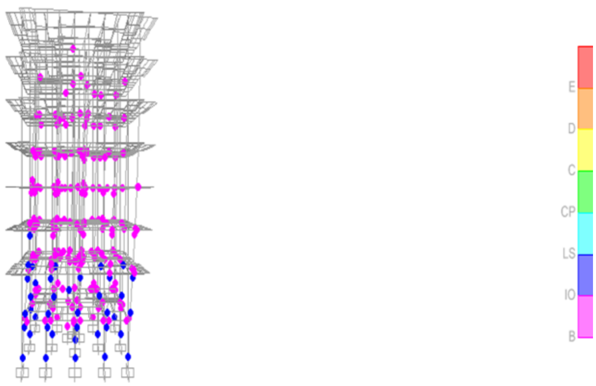
3.1.2. Performance Evaluation with Nonlinear Time History Analysis

It is assumed that nonlinear time history analysis defines structure behavior ideally because of the seismic loads directly applied to structure. The aim of nonlinear time history analysis is integration of equations of the motion of the system step by step by taking into consideration of nonlinear behavior of bearing system. It is calculated for each time increment that displacement, plastic deformation, internal forces occurred in the system and maximum values of them during earthquake.

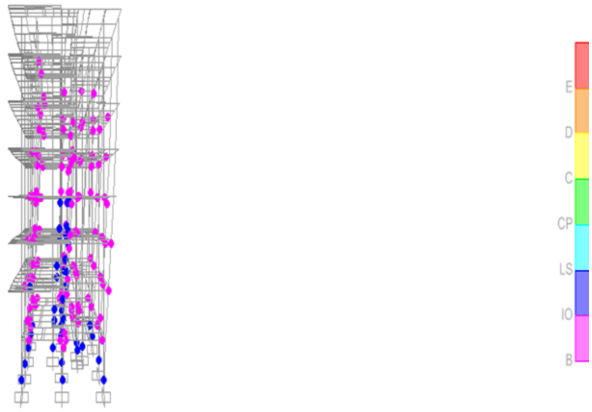
In addition to the static pushover analysis, in this study, performance evaluation of the selected building also is determined with nonlinear time history analysis, comparatively. Because the building is in Van provincial border, horizontal component of Van earthquake (Fig.9) is taking into consideration. The responses of the structure are computed via using the Newmark's method.

It is seen from Fig.10 that plastic hinges occurred through X and Y-directions as a result of nonlinear time history analysis. It can be seen from Fig. 10 that these hinges are concentrated on collapsing mechanism the Y direction. Because at the downstairs collapsing mechanism is occurred, the structure does not act its mission and it is collapsed completely.

When the analysis results are investigated, it is concluded from nonlinear time history analysis that according to damage conditions of elements, the building does not provide life safety (LS) rating in TBEC-2019. The existing residential building is far from satisfying the expected performance levels. The performance level of the building is determined as collapse (CO).



(a)



(b)

Fig. 8. The plastic hinges occurred through the X (a) and Y (b) directions of the building for design earthquake after pushover analysis.

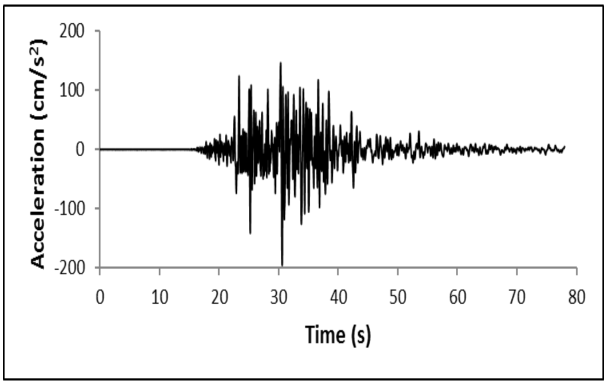


Fig.9. Acceleration time history of Van earthquake (NS6503), 2011.

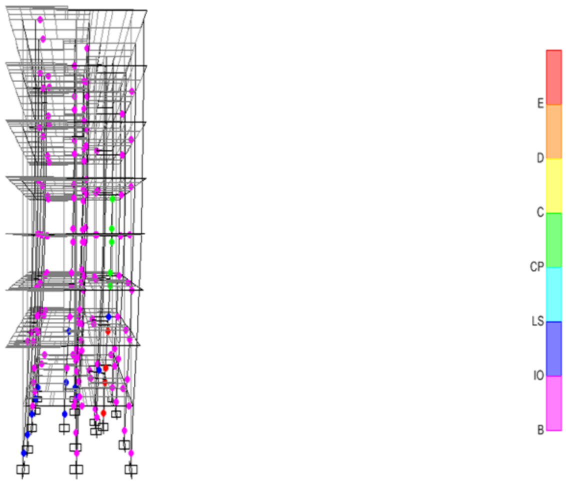


Fig. 10. The plastic hinges occurred through the YZ directions of the building for nonlinear time history analysis.

4. CONCLUSIONS

This paper investigates the seismic performance of an eight-story reinforced concrete shear wall hotel building designed according to the provisions of TEC-1975. The Pushover analysis was used to evaluate the seismic performance of the building. Performance evaluation is performed using the current Turkish Building Earthquake Code, TBEC-2019. The performance levels, MN, GV, and GÇ are considered as specified in this code and several other international guidelines such as FEMA-356 and ATC-40. Pushover analysis and criteria of TBEC-2019 were used to determine global displacements of the building corresponding to the performance levels considered above. Displacement volition estimates for earthquake with probability of exceedance of 10% in 50 years are compared for MN, GV and GÇ displacement capacities**.**

The pushover analysis is a simple way to explore the nonlinear behavior of the buildings. The results obtained in terms of pushover volition, capacity spectrum and plastic hinges gave an insight into the real behavior of structure. Pushover analysis is not only useful for evaluating the seismic performance of the structure, however, could also be helpful for selecting seismic details that are more suitable for withstanding the expected inelastic deformations. According to TBEC-2019, the reinforced concrete shear wall building is expected to satisfy life safety (LS) performance levels under design earthquake. Pushover can provide reasonably accurate estimation of the performance level when the reinforced concrete shear wall building is not the severely damage. While the building is serious collapsed, the pushover analysis underestimated the building performance, regardless of the lateral load distributions.

It is concluded from nonlinear dynamic analysis of the structure to the scaled ground motion that according to damage conditions of elements, the building does not provide life safety (LS) rating in TBEC-2019. The building is far from satisfying the expected performance levels.

In addition to these, the results from linear analysis and pushover analysis show lower damage ratios for the first story beams and columns than those of the nonlinear dynamic analysis.

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The Bamboo Greenhouse Technology for Hydroganic Crops with Independent Photovoltaic Electricity

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Abstract: The development of the city has made a lot of agricultural land turned into residential land and other urban facilities so that agricultural land becomes increasingly narrow so that it can weaken the food safety program. Another way is needed to utilize narrow land in an effort to develop agricultural products, namely by farming and maintaining fish hydroganic. Hydroganic comes from the words "Hydro" and "Organic" which are defined as organic cultivation systems by combining the hydro system and the organic system. The main source of nutrition from hydroganic is obtained from solid and liquid organic fertilizer and fish pond water that is treated as plant nutrition. The Hydroganic Technology Dissemination Program with independent electricity sources from solar power plants was carried out in Flower Village Grangsil, Jambangan Village, Dampit District, Malang Regency. Communities that are the perpetrators of the activities are the Tourism Awareness Group "Flower Village Grangsil" and the "Syakura Arum" Farmer Women's Group. The research method uses a descriptive qualitative method, beginning with the design, the creation of an Independent Energy Hydroganic Greenhouse and the planting of vegetables and fish stocking. Retrieval of data in the form of observations and documentation of photos and videos on activities: a) lectures and discussions; b) practice of making bamboo structures greenhouses; c) the practice of installing hydroganic plants; d) the practice of installing solar power plants; e) Hydroganic vegetable and fish growing practices. Through this program the construction of a tunnel-shaped greenhouse with bamboo structure has been carried out successfully, 2 (two) hydroganic farming facilities complete with fish ponds, 1 (one) solar power generation unit consisting of 4 solar panels each with a capacity of 100 wp with energy storage in the form of a 100 AH 12 V battery and a 1000 WH inverter in sunny conditions producing a minimum of 13.6 Amp, 18.8 V can meet the energy needs to drive the water circulation pump and greenhouse lighting lamps and the surrounding environment. Planting sla and mustard greens as well as spreading catfish and tilapia in mid-August 2019, lettuce vegetables can be harvested at the end of September 2019. The success that can be seen is that when farmers cannot grow vegetables in dry land, the vegetable plants in this hydroganic greenhouse remain fertile and healthy because water circulation occurs continuously. Tunnel-shaped greenhouse with bamboo structure using independent energy for hydropower farming is very practical, efficient and quick to build and can be planted with vegetables and spread fish throughout the year without pause is expected to be a prototype of modern agricultural and fishery facilities without relying on the rainy or dry season in the framework of the program increase national scale food safety.

Keywords: greenhouse, hydroganic, solar energy, food safety.

1. INTRODUCTION

Agriculture is a very important sector for the people of Indonesia. The agricultural sector is a source of income for some people, because most of Indonesia's territory is agricultural land. Farmers usually use the land for planting media, but along with the development of the city, many agricultural land has turned into residential land and other urban facilities so that agricultural land becomes increasingly narrow. So now there are other ways to use narrow land as an effort to develop agricultural products, namely by planting hydroganic. Hydroganic comes from the words "Hydro" and "Organic" which are defined as organic cultivation systems by combining the hydro system and the organic system. The main source of nutrition from hydroganic is obtained from solid and liquid organic fertilizer and pond water that is treated as plant nutrition. There are 3 important components in hydroganic applications, namely: 1) Ponds; 2) organic fertilizer (as a planting medium); and 3) wick system series (Yeniarta, 2017).

The advantages of farming in the hydroganic system are: 1) Higher yields and quality of plants; 2) More free from pests and diseases; 3) Use of water and fertilizer is more efficient; 4) Able to overcome land problems; 5) Can overcome the problem of land limitations. While the advantages are: 1) No need for tillage; 2) No need for crop rotation; 3) Uniform results; 4) Clean 5) High yields; 6) Less Labor (efficient); 7) Easier to maintain; 8) Easier to replace new plants; 9) Can be a place and way to improve plant quality

In East Java, the Hydroganic System began to be developed by the Mini Maxi Joint Business Group which formed the "Dream Workshop" association in Kanigoro Village, Pagelaran District, Malang Regency, and then was widely studied and disseminated through training and dissemination in various cities in Java and outside Java. The Hydroganic Technology Dissemination Program with independent electricity sources from solar power plants was carried out in Kampung Bunga Grangsil, Jambangan Village, Dampit District, Malang Regency. Communities that are the perpetrators of the activities are the Tourism Awareness Group "Flower Village Grangsil" and the "Syakura Arum" Farmer Women's Group.

2. LITERATURE REVIEW

2.1. Food Safety

Food safety has five elements that must be met: (a) Household and individual oriented; (b) Time dimension at any time when food is available and accessible; (c) Emphasis on household and individual food access, both physical, economic and social; (d) oriented towards fulfilling nutrition; and (e) Aimed at healthy and productive living (Suharyanto, 2011). One aspect that can encourage increased food safety is the use of yards.

Utilization of a yard or a limited home page can have maximum added value if done properly and has a clear concept. The existing plots of land are generally not utilized to meet food needs, even if implemented, are still part-time or free time. Puspitasari (2018) states that it is necessary to design a more comprehensive yard utilization plan to optimize the role of the plot as a buffer for household food safety. Yard with diversity in it also has a great potential to increase the carrying capacity of the environment. The urban agriculture movement can be the backbone in increasing community independence, especially maintaining food safety at the household scale. The limited land area gave rise to the choice of farming with a hydroponic system.

2.2. Bamboo Structure of Greenhouse

Greenhouse buildings are used to create optimal conditions in crop cultivation activities in a controlled environment (Anadia, Nafila, at.al. 2018). The plastic material is needed for the cultivation of hydroponic plants. The function of a plastic material is as a regulator of solar radiation that enters the greenhouse, besides that it also serves as a protection against plants from insects and birds (Hendra, 2015).

Bamboo is a local material that is widely available throughout Indonesia and especially in rural areas. With careful and perfect processing (preserving) efforts, the material from this bamboo material can become a construction material with emulsions that are strong enough / hard and durable (durable), so that it can be used for various types of practical benefits (Handoko, 2014) . Bamboo is also an ecological material that is easily rejuvenated and loaded with various benefits. All the elements that exist in the bamboo base (ranging from: stems, leaves, even to get the roots) can be widely used in various activities in daily community life.

2.3. Hydroganic Agriculture System

Hydroganic comes from the words "Hydro" and "Organic" which are defined as organic cultivation systems by combining the hydro system and the organic system. The main source of nutrition from hydroganic is obtained from solid and liquid organic fertilizer and pond water which is treated as plant nutrition (Yeniarta. 2017).

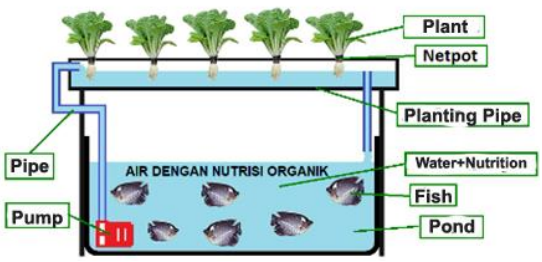

Figure 1. Hydroganic system

2.4. Photovoltaic Solar Energy Systems

The main component of a Solar Energy System is a photovoltaic cell that converts solar radiation into electricity directly (direct conversion) captured by the Solar Array, a Balance of System (BOS) required includes a charge controller and inverter, an energy storage unit (battery) and other supporting equipment (Widayana, 2012). This energy system will support the electricity needs of circulating water pumps that pump water from ponds to the pipe pipes where hydropower vegetables are planted.

Figure 2: Photovoltaic Solar Energy Systems
Source: Widayana, 2012

3. RESEARCH METHODS

This study uses descriptive qualitative methods and action research in the form of making a prototype of a greenhouse for hydroganic plants, conducting a trial of growing vegetables. The method of implementing technology dissemination activities to the community used in this activity are: a) lectures and discussions, namely providing knowledge and understanding of how to grow a hydroganic system and its benefits and benefits, discussion and questions and answers, the practice of hydropoweric farming; b) practice of making bamboo structures greenhouses; c) the practice of installing hydraulic plants; d) the practice of installing solar power plants; e) the practice of planting and maintaining vegetable plants in a hydroganic manner. The implementation was carried out in mutual cooperation by the people of Grangsil, Jambangan Village, Dampit District, Malang Regency. Lectures and discussions were held in several places according to the Village Head, in the Greenhouse, and at the "Dream Workshop", with the help of power point media and video; while the practice of growing vegetables and spreading fish seeds using hydroganic equipment.

Primary data in this study were taken with a variety of observations, namely: a) Greenhouse design, b) speed of greenhouse construction, c) speed of installation of hydroganic installations, d) Speed of solar power plan installation e). The workshop process The process of planting and maintaining vegetables.

4. RESULTS AND DISCUSSION

4.1. Design

The design of Hydroganic Vegetable Farm Greenhouse with Solar Energy System was carried out by the Construction Team for 15 days. The shape of the building uses a tunnel shape that makes it easy for the community to build it. While the building structure uses bamboo material, remember that in Grangsil area there are many bamboo plants for building construction.

The following figure shows a tunnel-shaped greenhouse design using bamboo structures with photovoltaic independent energy.

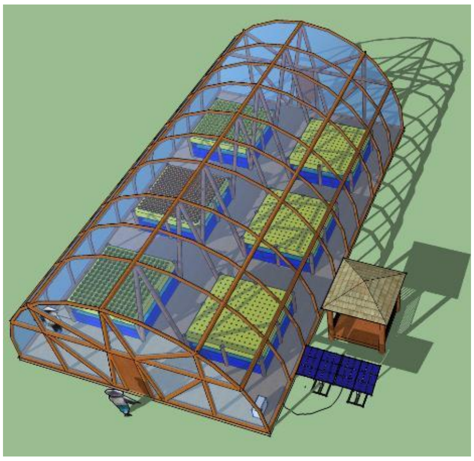

Figure 3. Design of a bamboo greenhouse for solar energy hydroganic agriculture (15 days)

4.2. Construction

a. Construction of a Greenhouse

The construction of a greenhouse with a bamboo structure was carried out cooperatively by the Grangsil hamlet community assisted by University of Merdeka Malang students who were doing a Real Work Lecture. It takes 15 days to complete the construction of a greenhouse with a bamboo structure.

Figure 4. Construction of a Greenhouse (15 days)

b. Hydroganic Installation

Hydroganic installation with materials: aluminum frame, paralon pipe, asbestos wave, tarpaulin; The implementation was carried out by the Jambangan community and Malang University of Merdeka Community Service students with direction from the University of Merdeka Malang Community Service Team and hydroganic experts from "Dream Workshop. Installation of this facility takes 6 days.

Figure 5. Hydroganic Installation (6 days)

c. Solar Power Plan Installation

Installation of Solar Power Plan installations include: solar panels, brackets, solar controllers, batteries, inverters, and cable networks leading to water pumps and lighting lamps carried out by the University of Merdeka Malang Community Service Team assisted by the people of Jambangan Village. Installation is carried out within 2 days.

Figure 6. PLTS Installation (2 days)

4.3. Socialization and Coordination

a. Coordination

Discussions in the form of and coordination were carried out in the field where hydropower was planted and in the house of the Head of Jambangan Hamlet.

Figure 7. Socialization of Hydroganic Agriculture

Figure 8. Coordination of the Hydroganic Management Team

4.4. Hydroganic Agriculture Workshop

Hydroganic agriculture workshops include: an understanding of hydroganic farming, how to make hydroganic media, how to plant and maintain hydropower plants carried out at the "Dream Workshop" in Kanigoro Village, Pagelaran District, Malang Regency.

Figure 9: Hydroganic Agriculture Workshop

4.5. Planting and Harvesting

Planting lettuce and mustard greens as well as spreading catfish and tilapia in mid-August 2019, lettuce vegetables can be harvested at the end of September 2019. The success that can be seen is that when farmers cannot grow vegetables in dry land, the vegetable plants in this hydroganic greenhouse remain fertile and healthy because water circulation occurs continuously. Tunnel-shaped greenhouse with bamboo structure using independent energy for hydroponic farming is very practical, efficient and quick to build and can be planted with vegetables and spread fish throughout the year without pause is expected to be a prototype of modern agricultural and fishery facilities without relying on the rainy or dry season in the framework of the program increase national scale food safety.

Figure 10: First Harvest of Lettuce Vegetable

4.5. Photovoltaic solar energy testing

The results of testing of each solar panel 100 wp are as follows:

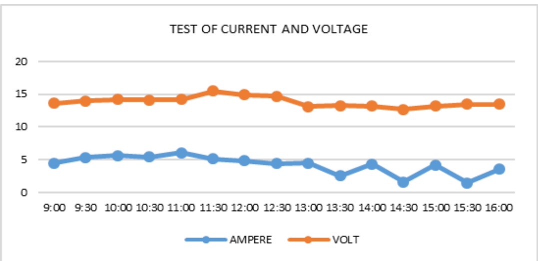

Figure 11. Graph of Current and Voltage of Solar Panels

In sunny weather, a 100 WP solar panel can produce an average of 4.2 Ampere 13.8 Volts, whereas when the weather is cloudy the current drops to 1.4 Ampere 6.07 Volts. Electrical energy stored in batteries can already be used to drive water pumps with a power of 38 Watt each 220 Volt voltage and lighting lamps both in the greenhouse and in the surrounding environment.

5. CONCLUSIONS AND SUGGESTIONS

5.1. Conclusions

a. The Greenhouse prototype with tunnel shape and bamboo structure material is a choice of beautiful, sturdy, and comfortable building forms used for hydroganic farming. Hydroganic agriculture is an example of an effort to succeed in a program to improve food safety by utilizing increasingly narrow agricultural land.

b. Planting vegetables as well as spreading fish, can be harvested at two months after planting. The success that can be seen is that when farmers cannot grow vegetables in dry land, the vegetable plants in this hydroganic greenhouse remain fertile and healthy because water circulation occurs continuously.

c. Tunnel-shaped greenhouse with bamboo structure using independent energy for hydroponic farming is very practical, efficient and quick to build and can be planted with vegetables and spread fish throughout the year without pause is expected to be a prototype of modern agricultural and fishery facilities without relying on the rainy or dry season in the framework of the program increase national scale food safety.

d. Hydroganic agriculture with solar energy independent electricity is an example of a very efficient farming system and the use of independent energy. This technology is very suitable for the needs of modern agriculture. Electrical energy requirements for water pumps and lighting can be met by 4 photovoltaic solar cell panels, in sunny weather it produces 13.2 Amperes of electricity, 19.2 Volts, so it doesn't need a generator or PLN electricity. This independent energy hydroganic greenhouse building can become a widespread prototype as a greenhouse building that is quickly built with independent energy.

5.2. Suggestions

a. Prototype of Greenhouse Agriculture Hydroganic solar energy independent electricity can be duplicated on a broader scale.

b. Further research can be done on the automation system in several parts to facilitate the hydroganic operation, including setting the time for fish feed and water circulation.

c. Further research can also be carried out on the use of bamboo as a substitute for paralon pipes for hydroganic farming.

6. ACKNOWLEDGMENTS

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a. The Ministry of Research, Technology and Higher Education, which has funded the disseminated products technology to the community.

b. University of Merdeka Malang which has become a place of community service

c. Tourism Aware Group and Women Farm Group as a Community Service Partner

d. Other parties who helped to realize the program and this paper

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