Disposable Knee Bracing in Combined Bracing System- Improvement in Seismic Design of Steel Frame using ETABS

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***Abstract*— Now a days, the use of braced frame systems has been expanded to achieve high stiffness and ductile structures in high seismic zones. Among the various types of bracing systems, such as x-brace ,diagonal etc. the knee bracing system has been mostly considered for seismic design in steel structures. In this system, the diagonal member provides the system's stiffness, and the knee member as a fuse provides the ductility and prevents the buckling of diagonal member; thus, it is expected that the stiffness and ductility of the structures will be remained strongly. In this study knee brace is integrated in the steel building with various bracing configuration and types of combined arrangement of different bracing (x type, diagonal inverted, chevron in frame is implied to test under Nonlinear Static Pushover (NSP) analyses, seismic analysis is carried out to compared with the corresponding concentric and eccentric frames. The output results like base shear, story drift, time period, and limit state check are compared and evaluated in ETABS.**

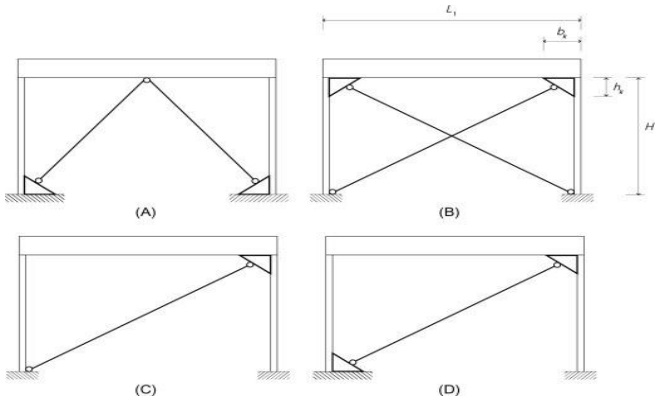
***Keywords*— Disposable knee brace,**

I. INTRODUCTION

The great strength, uniformity, light weight and many other desirable properties makes steel the material of choice for numerous structures such as steel bridges, high rise buildings, towers and other structures. Steel bracing provides an effective solution for resisting lateral forces in a framedstructures.

Knee braced steel frame has got excellent ductility and lateral stiffness. Since the knee element is properly fused, yielding occurs only to the knee element and no damage to major elements In recent years, the use of braced frame systems has been expanded to achieve stiff and ductile structures in high seismic zones. Among the various types of bracing systems, the knee bracing system has been specially considered for seismic design in steel structures. In this system, the diagonal member provides the system's stiffness, and the knee member as a fuse provides the ductility and prevents the buckling of diagonal member; thus, it is expected that the stiffness and ductility of the structures will be remainedsimultaneously.
In this study knee brace is integrated in the steel building with various bracing configuration types of combined arrangement of different bracing (x type, diagonal inverted, chevron)in frame is implied to test under Nonlinear Static Pushover (NSP) analyses, seismic analysis is carried out to compared with the corresponding concentric and eccentric frames.

2. OBJECTIVES



To develop and compare models of knee brace typein combined system in the steel frame against seismic force.

- Knee brace is integrated in the steel building with various bracingconfiguration.
- Combined arrangement of different bracing in frame taken such as X- type, diagonal, and chevron.
- The analysis carried out with and without DKB.
- Performing the nonlinear static pushover analysis to evaluate, yielding, ultimate displacement, lateral load, ductility and plastic hinge.
- Seismic analyses are carried out using nonlinear time history.
- The output results like bases hear, ductility, story drift, time period, limit state check are compared and evaluated in ETABS.
- Introducing new type of bracings, such as k-type knee brace, arch knee brace.

3. SUMMARY OF LITERATURE REVIEW

From the literature review the following conclusions were observed The knee-braced frames (KBF) include relatively simple connections for ease of construction and reparability after an earthquake and less obstruction as compared to conventional bracing systems. Lesser sway,

capable of resisting Knee braced steel frame is that of excellent ductility and lateral stiffness. A stiffener between a column and a supported truss or beam to provide greater rigidity in a building frame under transverse loads. Providing bracing is to control the buckling of the main beams, Reduction in lateral displacement is one of the major advantages of using bracing system.

4. SCOPE

The scope of the project is to investigate the seismic performance of combined bracing system in a multi-storey building with soft storey effect.

5. METHODOLOGY

- Literature review
- Multi -story steel building is considered here for this project work.
- Validating the steel structure with bracing system.
- The study is limited to develop and compare models with and without Knee brace in the steel building with combined bracing configuration.
- Performing dynamic analysis for the seismic performance.
- Drift, displacement, base shear, time period and natural frequency.
- Compilation, conclusion and discussion of result.

5.1 Dimensions:

All measurements are centre line;
The referenced structure of this study is a 16-storyFloor height =3.1 m,
Total height of building= 16 × 3.1 m =49.6 m residential steel high-rise building .
The typical floor plan= 15m× 15m,
Building consists of three bays (3 × 5 m) inlongitudinal and transverse directions.
Columns:
Column sizes change at splices, corner columns and interior columns the same size, throughout elevation; box columns are
Loads;
For seismic design with a dead load of 6kN/m2 and a live load of 2 kn/m2.

Beam-IPE 220, IPE240,IPE 300,(European standard I sections(EN 10365)Bracing-UNP 160
Knee brace =IPE100

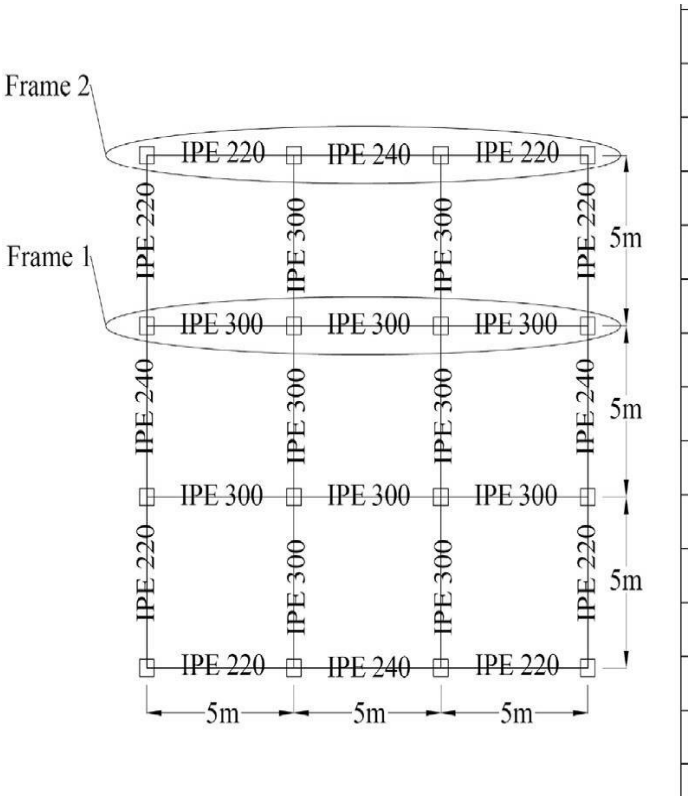


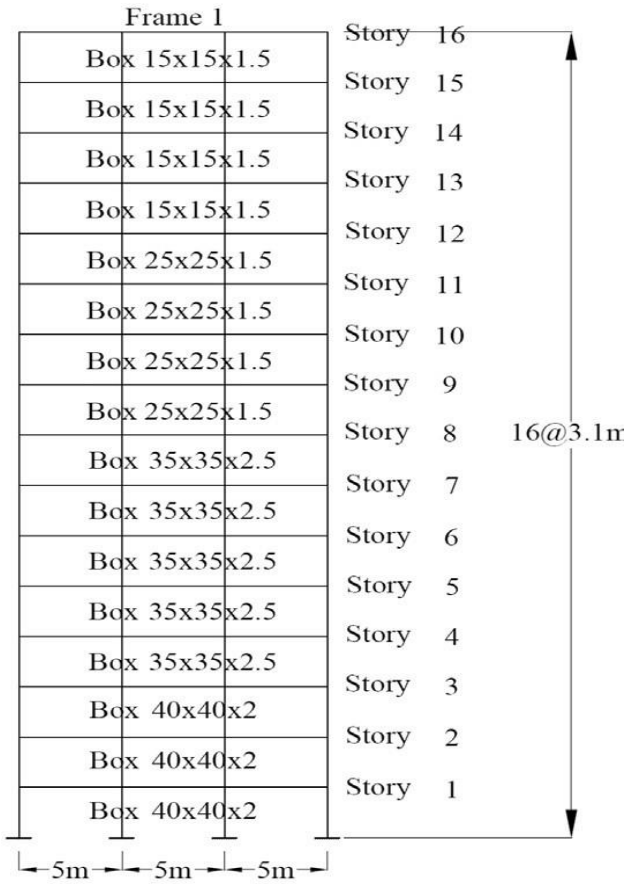
Fig : Plan of the building

5.2. ETABS Software

ETABS is design software which is indicate thar "Extended Three-Dimensional Analysis of Building System". ETABS is widely 3 Dimensional modelling software for any kind of structural analysis and design. Using this helps to analyse both the steel structure and RC Structure. This software which is used in construction field. Static and dynamic analysis of multi-storey frame is highly. It's the famous civil construction designing tools used in the building industry and increases the productivity of structural engineers.

It prevents the unnecessary time and money. Getting correct value about the structure.

Fig 2: Elevation of the building



6. MODELLING

G+16 building with and without braces is modelled using ETABS. Bracing is one of the best method used to overcome lateral buckling. Bracing is provided I he building for the reduction of lateral deflection. The bracing system gives best result in lateral stiffness, strength capacity as well as in displacement capacity. The soft storeys are given at higher, because it give safe and best result. A soft storey has inadequate shear resistance or inadequate ductility or energy absorption capacity to resist earthquake inducedbuilding stress.

The Models considered in this project are,

1. Modeling a multistory steel building without bracing system
2. Modeling of building with Knee braceonly braced
3. Modeling of building with X-Brace withknee
4. Modeling of building with Diagonal bracing with knee
5. Modeling of building with V- bracing withknee
6. Modeling of building with Inverted V-bracing with knee

Dynamic analysis is considered for theevaluation performance in ETABS

Model analysis is carried out to evaluate the time period and frequency of structure Time history analysis with PGA earth quakedata is applied for seismic performance,

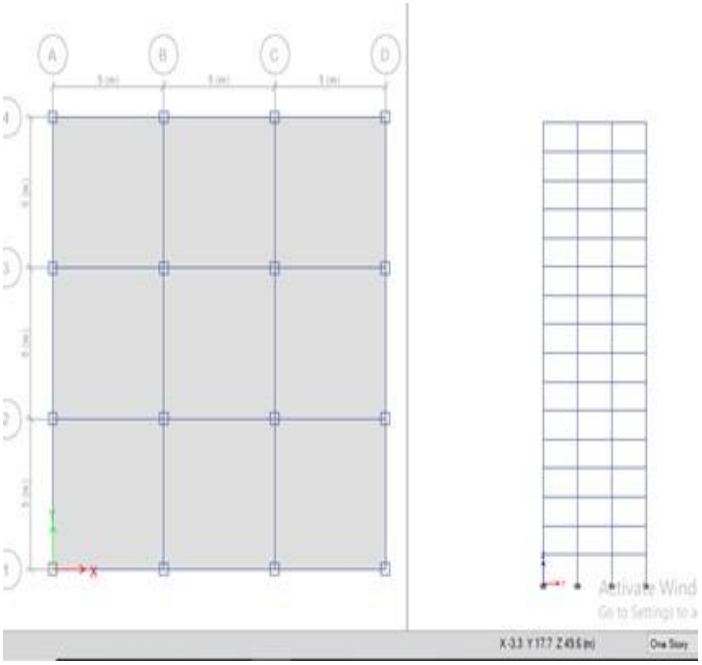


Fig 3:Building a) Plan view b

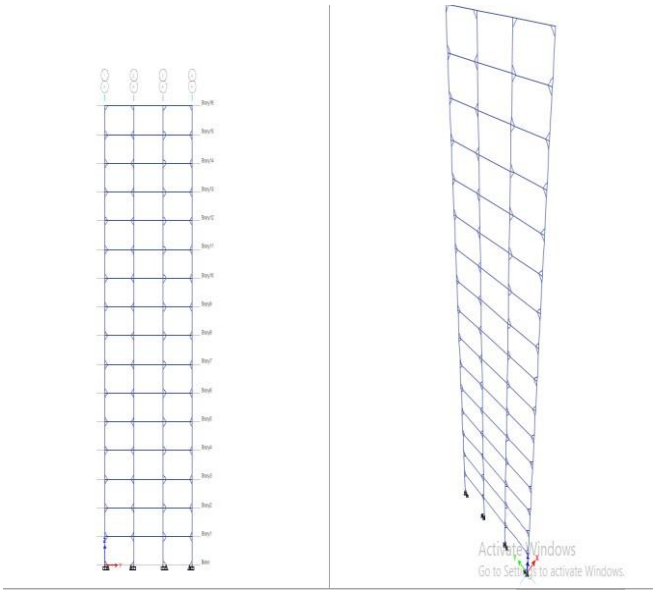


Fig 2: Building with knee brace a) Elevation view b) 3D view

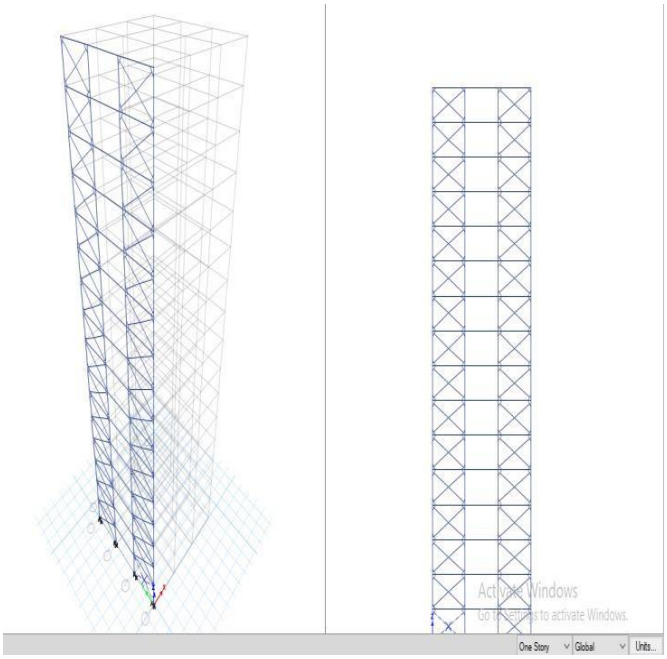


Fig 4: Building with X-KNEE brace a) 3D view
b) Elevation view

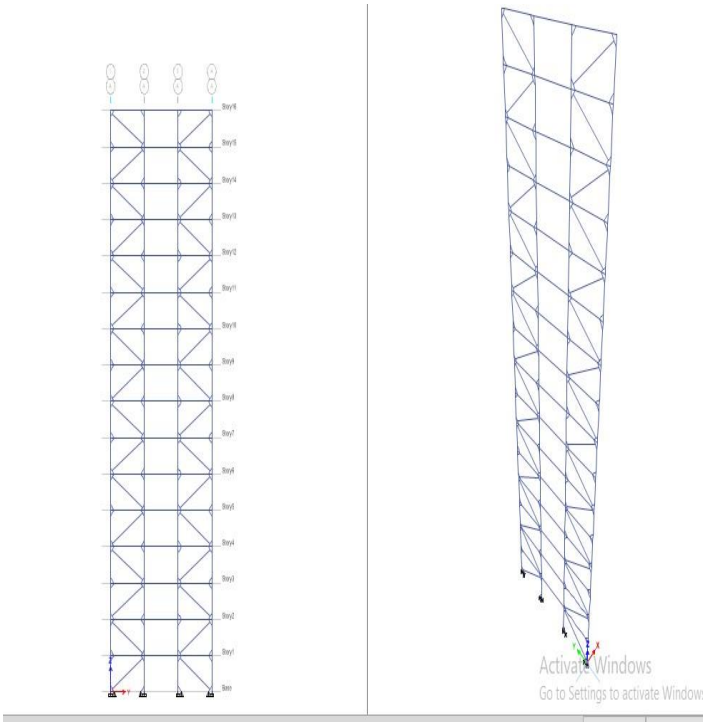


Fig 6 .Building with Diogonal -knee brace a)Elevation view b) 3D view

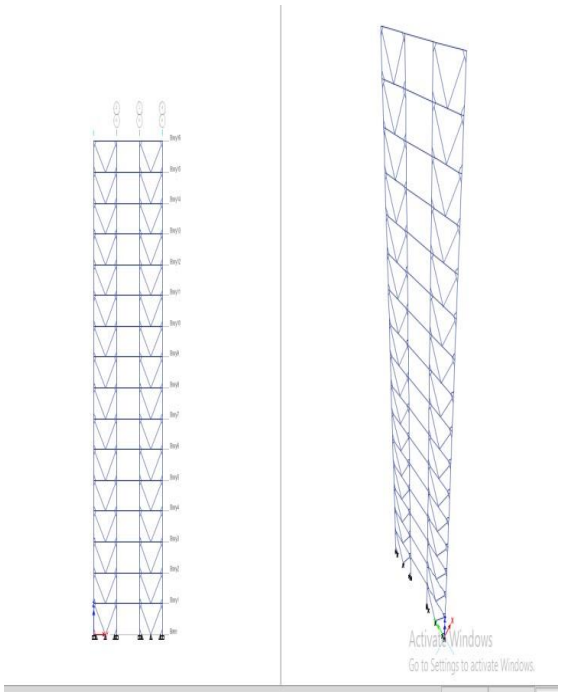


Fig 5 .Building with V-KNEE brace a) Elevationview

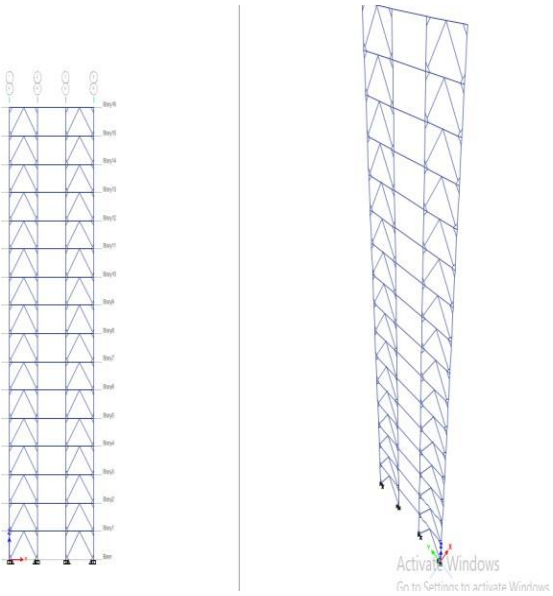
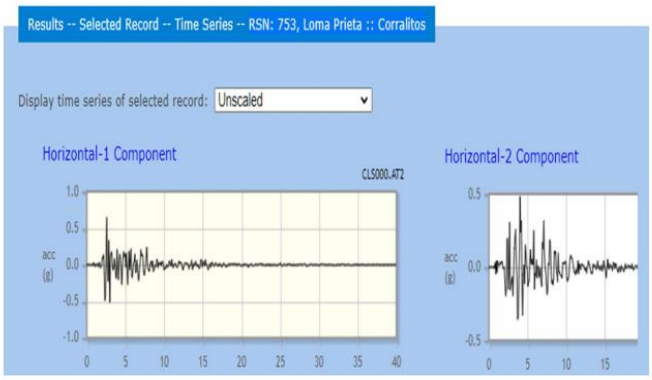


Fig 7 .Building with Inverted V-KNEE brace a) Elevation view b) 3D view

After the modelling of building, the material and frame properties are defined. Model 1, Model 2, Model 3, Model 4,model 5,model 6 are under different bracing configuration;

7. ANALYSIS

ETABS software was used to develop the 14 models. Modal analysis is performed to get the information regarding different configuration of knee brace different shape that can be taken up by structure during vibration. For the evaluation of seismic response of frames under seismic loading in case of time history analysis or dynamic analysis, frames were subjected to earthquake ground acceleration of Corirlite. Details of Corilite earthquake are downloaded from the site peer.berkeley.edu. Before the dynamic analysis Corilite details are to be added to time history function definition file shown in Fig below. Pushover analysis, the simplest method performed to evaluate the performance of structures in terms of structure displacement-base shear , Time period In this investigation, the horizontal ground motion records of the RSN: 753, Loma Prieta :: Corralit from PEER ground motion data base have been selected for performing the nonlinear dynamic THanalysis



The values of storey drift that is the inter storey displacement for two consecutive floors, displacement and storey shear obtained from analysis are tabulated.

After the analysis of Bare frame x-brace with knee brace, diagonal with knee brace, chevron brace with knee, v brace with knee braced multi-storey building, displacement and drift values of each storey level is obtained and are provided in Table 1 to Table 6. Table 6 compare the performance of each model and Bare frame model. It is found that exterior x brace and inverted v brace in multi-storey building is more effective.

Table1 : Displacement and drift of each story
Bare frame

BARE FRAME -		
STORY NO	DISPLACEMENT(mm)	DRIFT
16	222.363	0.009489677
15	192.945	0.010562581
14	160.201	0.009123548
13	131.918	0.005144516
12	115.97	0.005416452
11	99.179	0.005372258
10	82.525	0.005091935
9	66.74	0.00447871
8	52.856	0.003887742
7	40.804	0.003511613
6	29.918	0.002441935
5	22.348	0.002163226
4	15.642	0.001935161
3	9.643	0.001582903
2	4.736	0.001099032
1	1.329	0.00042871
Base	0	0

Table2 : Displacement and drift of each story Of knee braced frame

KNEE ONLY		
STORY NO	DISPLACEMENT(mm)	DRIFT
16	210.66	0.000862903
15	184.95	0.001093548
14	155.79	0.001395806
13	135.003	0.001827419
12	118.701	0.002273548
11	101.434	0.002594839
10	84.301	0.002970323
9	68.081	0.003395161
8	55.06	0.00369129
7	45.484	0.003803226
6	35.899	0.003823871
5	26.629	0.00370129
4	18.107	0.003367419
3	11.109	0.002822903
2	5.43	0.002033871
1	1.506	0.000923226
Base	0	0

Table3 : Displacement and drift of each story Of X-knee brace

KNEE WITH -X BRACE		
STORY NO	DISPLACEMENT(mm)	DRIFT
16	116.152	0.00092
15	113.3	0.001176452
14	109.653	0.001482581
13	105.057	0.001856452
12	99.302	0.002057419
11	92.924	0.002303226
10	85.784	0.002635806
9	77.613	0.003028065
8	68.226	0.003320968
7	57.931	0.003429677
6	47.299	0.003474516
5	36.528	0.003389677
4	26.02	0.003107419
3	16.387	0.002622258
2	8.258	0.001886774
1	2.409	0.000777097
Base	0	

STORY NO	DISPLACEMETNT	DRIFT
16	125.8	0.862903
15	123.125	1.093548
14	119.735	1.395806
13	115.408	1.827419
12	109.743	2.273548
11	102.695	2.594839
10	94.651	2.970323
9	85.443	3.395161
8	74.918	3.69129
7	63.475	3.803226
6	51.685	3.823871
5	39.831	3.70129
4	28.357	3.367419
3	17.918	2.822903
2	9.167	2.033871
1	2.862	0.923226
0	0	

Table4 : Displacement and drift of each story

Of v-knee brace frame

Table5 : Displacement and drift of each story

Of diagonal-knee brace

KNEE WITH - DIAGONAL- BRACE		
STORY NO	DISPLACEMENT	DRIFT
16	171.548	0.001512581
15	166.859	0.002120323
14	160.286	0.002896129
13	151.308	0.003768387
12	139.626	0.004397419
11	125.994	0.004672581
10	111.509	0.004886129
9	96.362	0.004910968
8	81.138	0.004800968
7	66.255	0.004649355
6	51.842	0.004374839
5	38.28	0.003684194
4	26.859	0.00328129
3	16.687	0.002712581
2	8.278	0.001900323
1	2.387	0.00077
Base	0	

Table6 : Displacement and drift of each story

Inverted v –knee brace

KNEE WITH INVERTED -V BRACE		
STORY NO	DISPLACEMENT	DRIFT
16	114.018	0.000858065
15	111.358	0.001099355
14	107.95	0.001383871
13	103.66	0.001750968
12	98.232	0.002119032
11	91.663	0.002372903
10	84.307	0.002682258
9	75.992	0.003038065
8	66.574	0.00329
7	56.371	0.003381935
6	45.887	0.003407419

5	35.324	0.003303871
4	25.082	0.003010323
3	15.75	0.002525161
2	7.922	0.001810968
1	2.308	0.000744516
BASE	0	0

From the result of bracing system shown in Table 3, inverted v-brace-with knee braced model is better and exhibit smaller storey displacement and drift values than other braced models. cheveron model has got less time period and weight than x brace model. Inverted v braced model showed 42.47% decrease in dispalcement than other models. Thus model 6 is considered as the most effective model.

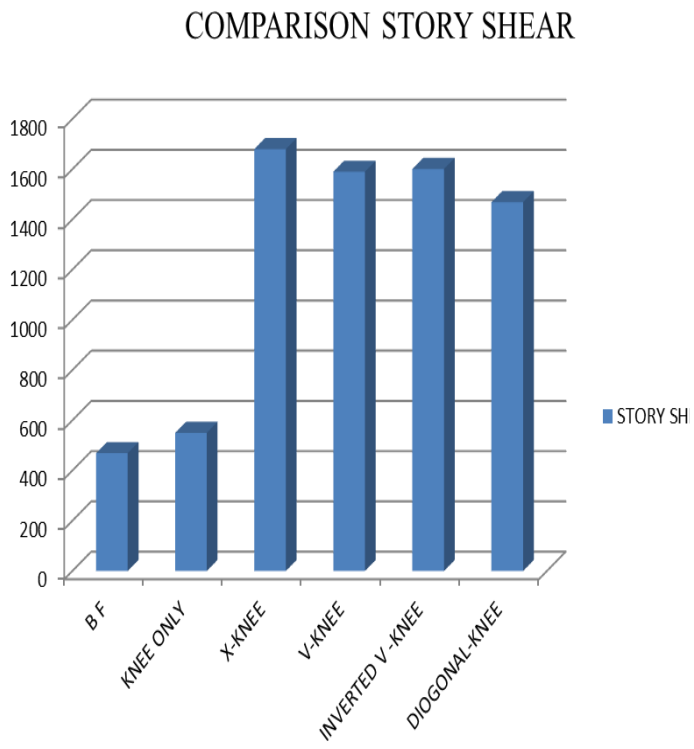
8. RESULT AND DISCUSSION

Table7 : comparison table of different braced configuration

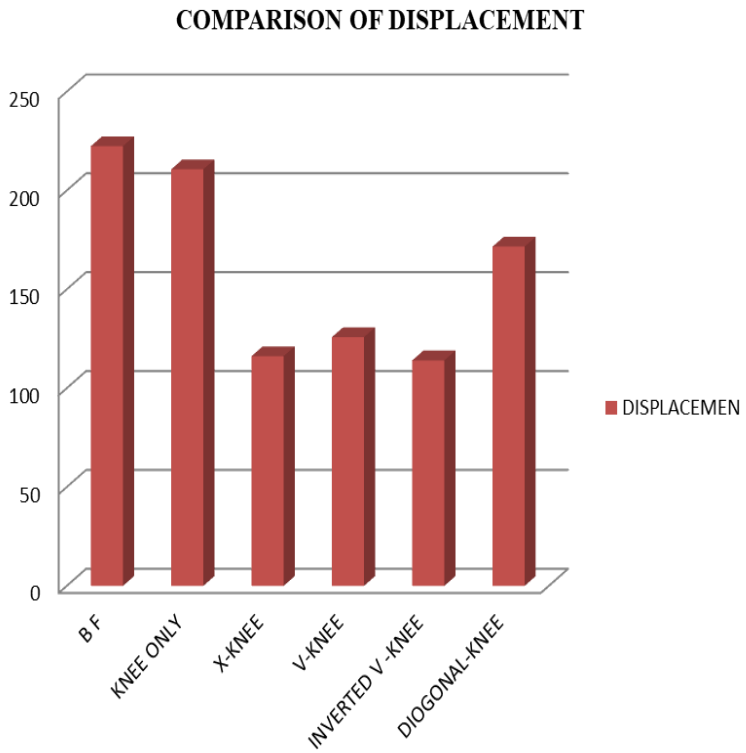
MODEL	DISPLACEMENT	BASE SHEAR
AXIS	Y	Y
Bare Frame	222.363	469
KNEE ONLY	210.66	550
X-KNEE	116.152	1680
V-KNEE	125.8	1590
INVERTED-V -KNEE	114.018	1601

TIME PERIOD	DRIFT	% DECRECE IN DISPLACEMENT
Y	Y	
1.1615	0.0044	
1.1287	0.0038	5.263015879
0.544	0.00347	47.76469107
0.56	0.00382	43.42583973
0.53	0.0034	48.7243831
0.65	0.00461	22.85227309

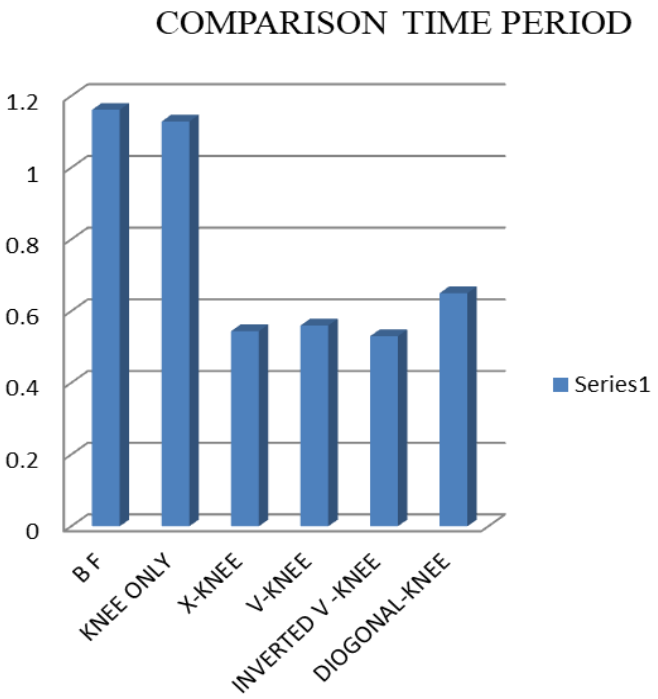
Graph 1.Comparison sory shear



Graph 2; Comparison of storey displacement



Graph 3.Comparison sory shear



After the analysis and comparison of all the graph and tables the following result were obtained,

1. in different bracing configuration, x brace with knee braced frame perform better than v brace and diagonal braced frame, due to lower displacement, drift and time period.
2. Inverted v brace with knee braced frame showed 48% decrease in displacement than other.
3. Diagonal bracing is not effective comparing the result with bare frame model. So we had taken combination x- brace and inverted v brace.

From the study on the above models, it is concluded that bracing is one of the best method used to resist earthquake forces. It increase the strength in member and overall stiffness of the building.

9..CONCLUSIONS

In this project, ETAB Software is used to analyse the Disposable knee brace in the different bracing bracing system. The following conclusions are arrived from the study

1. It was observed that, from different bracing configuration model, Inverted V brace with knee braced multi-storey building perform better than X, V,DIOGONAL, and BARE frame model.
2. Inverted V –KNEE braced model exhibited low displacement and drift.
3. 48% decrease in displacement was observed.
4. Hence, for the combined braced system, the combination of the best two systems as INVERTED V –KNEE, X-KNEE brace were taken.

10.REFERENCES

[1] MING-TUCK SAM et.al “preliminary studies into the behavior of knee braced frames subject to seismic loading”(2012).
[2] M.T. ROUDSARI ET.AL “Seismic behavior evaluation of knee braced framesbased on push-over and cyclic analyses” (2014).
[3] HOSSEINI HASHEMI et.al “Eccentrically knee bracing: improvement in seismic design and behavior of steel frames"(IRJET 2015).
[4] R.S. LONDHE ET.al “Nonlinear static analysis of knee bracing in steel frame structures” (2015).
[5] .SHINDE, R et.al “Analytical study of braced unsymmetrical rcc building” (ijsr) 2015, volume 4
[6] SHALAKA DHOKANE et.al “A study on the effectiveness of bracing systems in soft story steel buildings” (irjet) 2016”.
[7] BEHROKH ET.AL “eccentrically knee bracing: improvement in seismic design and behavior of steel frames” (2016 jsee) [8]. PRAVIN S ET.AL, “lateral load analysis of a building with & without kneebracing” (2016, irjte)
[8] M. N. CHIMEH.ET.AL “efficiency of bracing systems for seismic rehabilitationsteel structures” (irjet) 2016
[9] DATIO ARISTIZABA .et al “Disposable knee bracing improvement in seismic design of steel frames” (irjet)2016”
[10] HAMEDJALAVAND,et.al, “Evaluating seismic capacity of steel frames with knee bracing”.(ijrte 2017)
[11] PINKN.ARTWANIET.A“optimam knee bracing system and orientation forhigh ristebuildinglateral loads” (ijar)-2017)
[12] NITHIN JOSEPH ET.al “steel frames with knee braces based onpushover analysis” (ijrte 2017)
[13] ZASIAH TAFHEEM .ET.AL “structural behavior of steel building with concentric and eccentric bracing: a comparative study” (ijrte) 2017

[14] GAYATRI THAKRE.ET .AL "effect of steel bracings in steel structure" (ijser)2017
[15] Suyog Sudhakar .et al "Evaluating Seismic Efficiency of Combination of Bracing for Steel Building" (2017)
[16] SARA RAPHAEL "a comparative study of knee braced steel frame" (irjet)2017
[17] AMIN MOSHTAGH, "seismic performance evaluation of knee and EBF braced frames using nonlinear static analysis" (ijsea) 2018
[18] ARUNROYNS , et.al „seismic performance of different bracing for steel frames" (ijrte)volume8, issue-1, may 2019
[19] KETAN CHAUDHARY et.al "effect of bracing and embracing in steel structures by using etabs" ((irjet), 2019 Disposable knee bracing in combined bracing system-improvement in seismicdesign of steel frame using ETABS 12
[20] K. KANISH et.al "analysis of frames with and without knee bracing for lateral [load using steel structures"((irjmt)2019 [22].KHATIBI. et.al. "cyclic behavior of the knee braced system considering thetype of knee joint" (2019)
[21] ROHIT SHINTRE "investigation of behavior of combined effect of x and diamond bracing system for high rise steel structure"(ijraset)2020 [24].HUSSAMN.MAHMOUD.et.al"seism I c collapse risk assessment of braced frames under near-fault earthquakes"2021
[22] .JUNLINLIA et.al "development and experimental study of steel beam-through framed connections with t-type curved knee braces for improving seismic performa