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Seismic and Structural Behavior of Building with Different Combination of Bracing

Linu Shaji[1], Sreedevi Lekshmi[2]

[1]P G Scholar, Department of Civil Engineering, Sree Buddha College of Engineering, Pathanamthitta, India

[2]Assistant Professor, Department of Civil Engineering, Sree Buddha College of Engineering, Pathanamthitta, India

Abstract: ***Steel structures played an important role in construction industry .It providing strength, stability and ductility. A study regarding the seismic response of steel structures is necessary. In the present study, modeling of the steel braced structures with different combination of bracing and analyses structure using STAAD pro v8i software. Bracing element in structural system plays vital role in structural behavior during earthquake. In this study there are four types of bracing are used. Such as X bracing, V bracing, inverted V bracing, and knee bracing. The combinations from these bracing are X and V type bracing, X and inverted V type bracing, X and Knee type bracing, V and inverted V type bracing, V and Knee type bracing , Knee and inverted V type bracing.Response spectrum method is used for seismic analysis. Comparison between the seismic parameters such as base shear, roof displacement, storey drift, for steel frame with different combination of bracing are studied.***

Keywords: steel frame, staad pro v8i, steel bracing, base shear, roof displacement, storey drift

1. Introduction

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. Strengthening of structures proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacement of buildings. Moreover it has been often seen that retrofitting of buildings is generally more economical as compared to demolition and reconstruction. Therefore, seismic retrofitting or strengthening of building structures is one of the most important aspects for mitigating seismic hazards especially in earthquake prone areas. Bracing element in structural system plays vital role in structural behavior during earthquake. Steel bracing is an effective and economical solution for resisting lateral forces in a framed structure. There are two types of bracing systems, Concentric Bracing System and Eccentric Bracing System. The Bracing is concentric when the center lines of the bracing members intersect. Concentric bracings increase the lateral stiffness of the frame, thus increasing the natural frequency and also usually decreasing the lateral drift. In an eccentrically braced frame bracing members connect to separate points on the beam/girder. Different type of bracing patterns such as X, V type, Inverted V type and Knee bracing are considered in this work.

1.1 Objectives

1) To study the seismic effect in steel braced structure.
2) To compare seismic performance of all(X, V type, Inverted V type and Knee bracing) types of bracing and find out which bracing is efficient in seismic prone area.
3) To study the seismic effect in steel braced structure with different combination of bracing.
4) To compare seismic performance of steel braced structure without combination of bracing and with different combination of bracing.
5) To compare seismic performance of all [(X,V), (X,invertedV), (X,Knee) (V,inverted V), (V,Knee), (Knee, invertedV)]combination of bracing and find out which combination is efficient in seismic prone area.

2. Details of the Building

The length and width of building is 9 m. height of typical storey is 3m. Building is symmetrical to X and Y axis.The non-structural element and components that do not significantly influence the building behavior were not modeled. The joint between Beams and columns are rigid. The columns are assumed to be fixed at the ground level. Following are the Description of a building. In this study, A G+4 storey steel building of 3 bays have been considered for investigating the effect of combination of bracings. Below table shows the detauls of building that is used for the analysis of building. Same identical rolled steel sections are used for all bracing patterns. The building are analyzed for earthquake loading. The building frames have been analyzed using response spectrum method in StaadproV8i, which is based on stiffness matrix method of analysis.

Following identical rolled steel sections are used for beams, columns and bracings.
Beam: ISLB 200
Column: ISHB 250,Bracing: ISMB 175

Table 1: Details of the Building

Sl No	Building Description	
1	Bay width	3m
2	Floor to floor height	3m
3	Total height of building	15
4	Grade of steel Fe 250	Fe 250
5	Live load	3 KN/m^2
6	Zone	V
7	Zone factor	0.36
8	Reduction factor	1
9	Importance factor	1.0
10	Column details	ISHB 250
11	Beam details	ISLB 200
12	Bracing details	ISMB 175

3. Modeling

There are the maximum six combinations created from four bracing such as X type, V type, inverted V type, and Knee type. In the present study, modeling of the steel braced structures with different combination of bracing and analyses structure using Staad software. The combinations of bracing used are

a) X and V type bracing
b) X and inverted V type bracing
c) X and Knee type bracing .
d) V and inverted V type bracing
e) V and Knee type bracing
f) Knee and inverted V type bracing

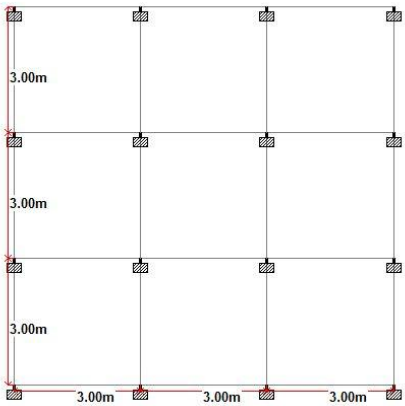

Figure 1: Plan of the building

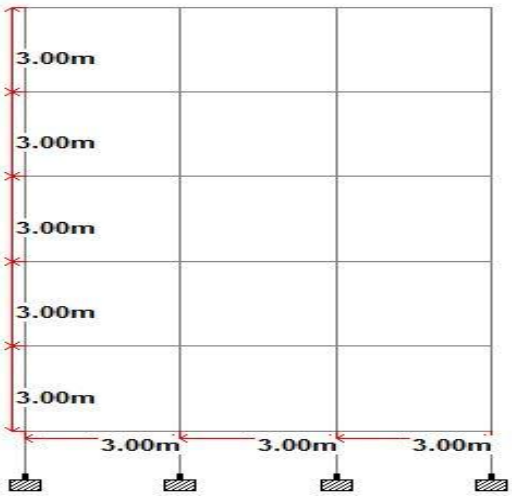

Figure 2: Elevation of the building

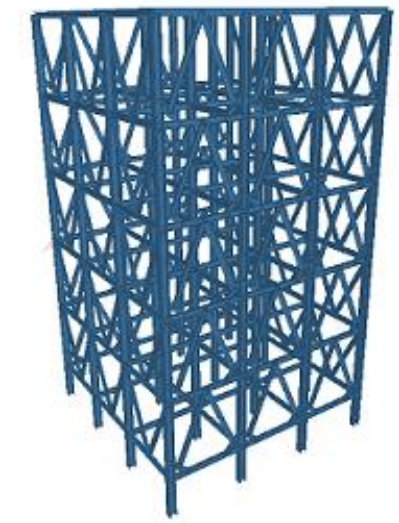

Figure 3: V and Knee type bracing

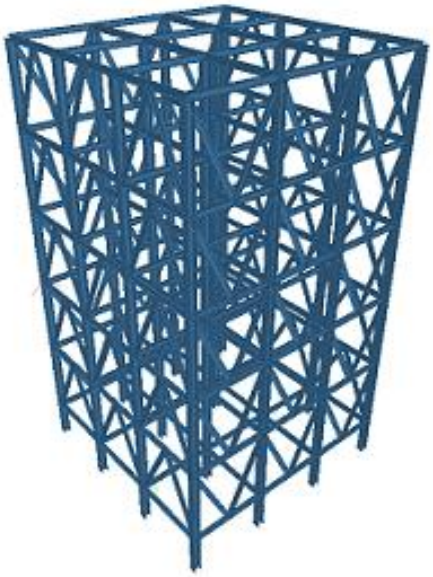

Figure 4: V and inverted V type bracing

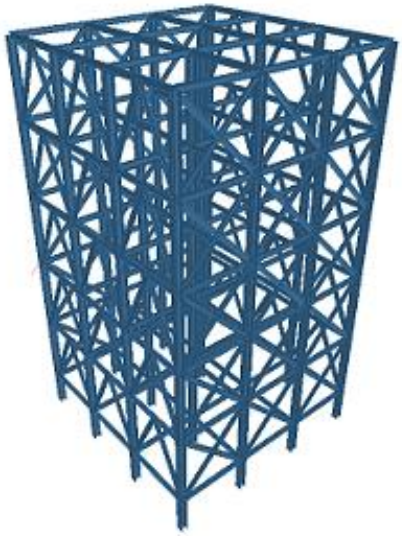

Figure 5: X and inverted V type bracing

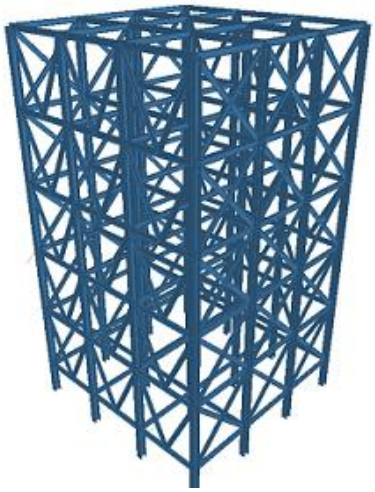

Figure 6: X and V type bracing

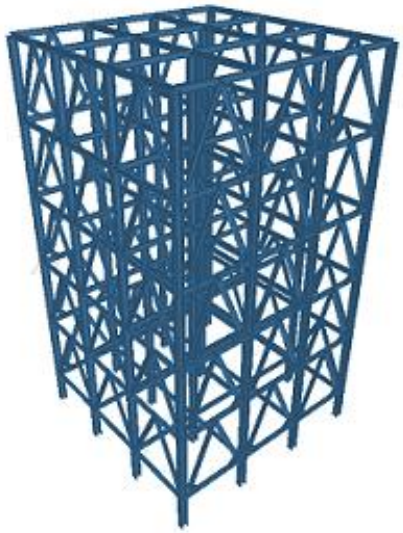

Figure 7: Knee and inverted V type bracing

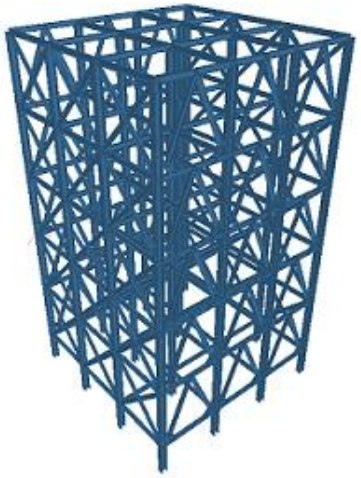

Figure 8: X and Knee type bracing

4. Analysis of Models

Model is analysed by using STAAD Pro. Base shear is find out by response spectrum analysis. This is accurate method of analysis. Below table shows the storey level and average displacement along x direction for different types of combination of bracing patterns such as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing,X and Knee type, and Inverted V and Knee type bracing.

Table 2: Average displacement along Z direction

Storey Level	X & Inverte V	V & Inverte V	V & Knee	X & V	X & Knee	Inverted V & Knee
1	0.2336	0.2343	0.2474	0.2467	0.2374	0.242
2	0.7346	0.8447	0.94	0.7488	0.9915	0.9323
3	1.2916	1.5327	1.7328	1.3139	1.8615	1.7209
4	1.8379	2.2069	2.5059	1.8676	2.7154	2.4904
5	2.3116	2.7897	3.1679	2.348	3.4521	3.1496
6	2.634	2.7068	3.8381	3.4442	3.6605	3.1187

Below figure shows the graph with average displacement along x direction and storey level along y direction

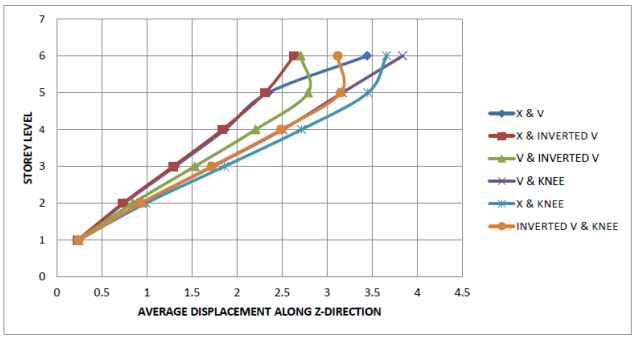

Figure 9: Average Displacement in Z direction

From the above table and graph shows combination of X and inverted V bracing have lower displacement value than any other combination of bracing. combination of X and inverted V bracing have smooth regular curve.

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Below table shows the storey level and average displacement along x direction for different types of combination of bracing patterns such as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing,X and Knee type, and Inverted V and Knee type bracing.

Below figure shows the graph with average displacement along x direction and storey level along y direction

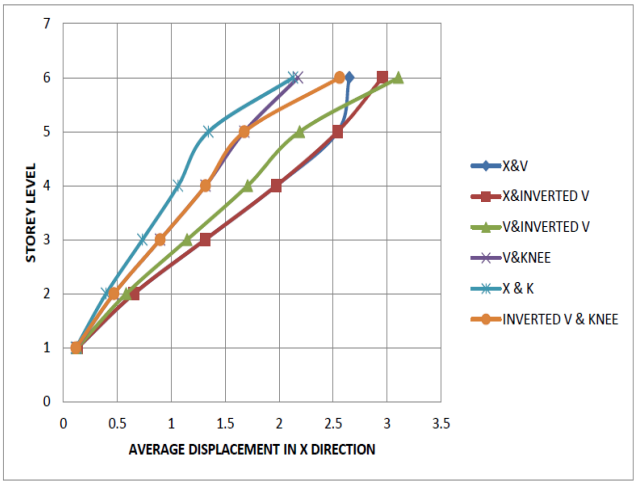

Figure 10: Average Displacement in X direction

Below table shows the storey level and storey drift along Z direction for different types of combination of bracing patterns such as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing,X and Knee type, and Inverted V and Knee type bracing.

Table 3: Average displacement along X direction

Storey Level	1	2	3	4	5	6
X&V	0.1318	0.6528	1.3132	1.973	2.5422	2.6502
X&InverteV	0.1284	0.652	1.312	1.9713	2.5403	2.9564
V&InverteV	0.1254	0.5818	1.1463	1.7074	2.19	3.1064
V& Knee	0.1209	0.4688	0.8964	1.3179	1.6772	2.1746
X & Knee	0.1155	0.3954	0.7325	1.0633	1.345	2.1283
Inverted V & Knee	0.1155	0.4684	0.8961	1.3174	1.3174	1.3174

Table 4: Storey Drift along X direction

Storey Level	X & Inverte V	V & Inverte V	V & Knee	X & V	X & Knee	Inverted V & Knee
1	0.2336	0.2343	0.2474	0.2467	0.2374	0.242
2	0.5009	0.6104	0.5523	0.5022	0.6178	0.5497
3	0.557	0.688	0.6563	0.565	0.8437	0.6514
4	0.5463	0.3743	0.6664	0.5537	0.9752	0.6627
5	0.4737	0.5827	0.6078	0.4804	1.0264	0.6052
6	0.3224	0.0825	0.6917	1.0962	0.6717	0.0087

Below figure shows the graph with storey drift along x direction and storey level along y direction

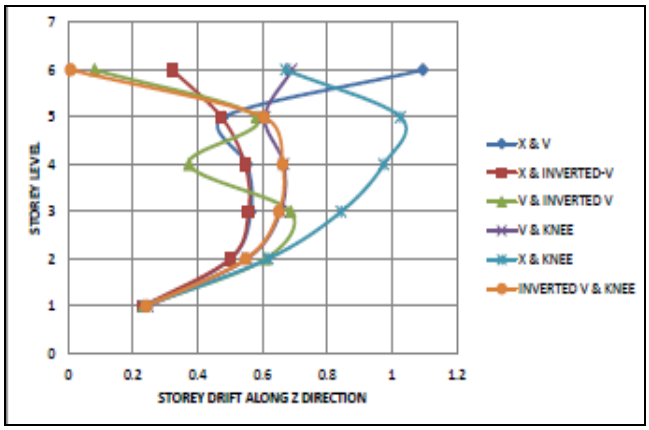

Figure 11: Storey Drift in Z Direction

Below table shows the storey level and storey drift along X direction for different types of combination of bracing patterns such as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing,X and Knee type, and Inverted V and Knee type bracing.

Table 5: Storey Drift along X direction

Storey Level	X & Inverted V	V & Inverted V	V & Knee	X & V	X & Knee	Inverted V & Knee
1	0.1284	0.1254	0.1209	0.1318	0.1155	0.1155
2	0.5236	0.4565	0.3563	0.521	0.2804	0.3559
3	0.66	0.5645	0.6996	0.6605	0.5319	0.6994
4	0.6593	0.5611	1.0347	0.6598	0.7753	1.0345
5	0.5691	0.4826	1.3129	0.5693	0.9753	1.3132
6	0.4161	0.9164	1.743	0.1079	1.6911	2.1287

Below figure shows the graph with storey drift along x direction and storey level along y direction

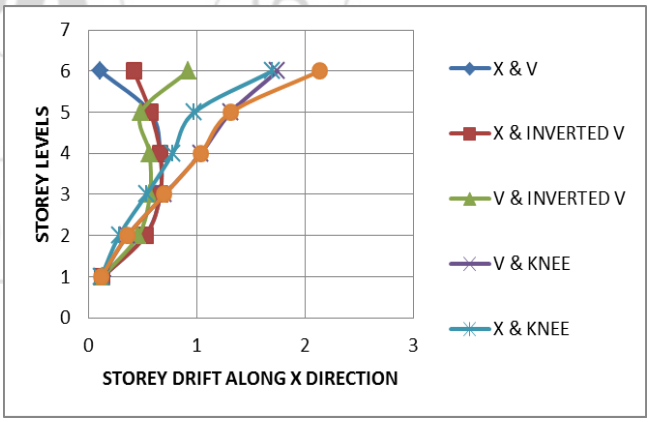

Figure 12: Storey Drift in X Direction

From above table and graph such as average displacement along z direction, average displacement along x direction,storey drift along z direction and storey drift along x direction shows combination of x and inverted v bracing give a smooth regular curve. Comparing these graph and table combination of x and inverted v bracing is more effective than any other combination bracing in terms of average displacement and storey drift.

Another effective way to find out the better combination is plotting the maximum storey drift and maximum

displacement of each combination of bracing such as as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing,X and Knee type, and Inverted V and Knee type bracing.

The below figure shows the graph plotted for maximum displacement along Z direction and maximum displacement along X direction of different combination of bracing such as as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing, X and Knee type, and Inverted V and Knee type bracing

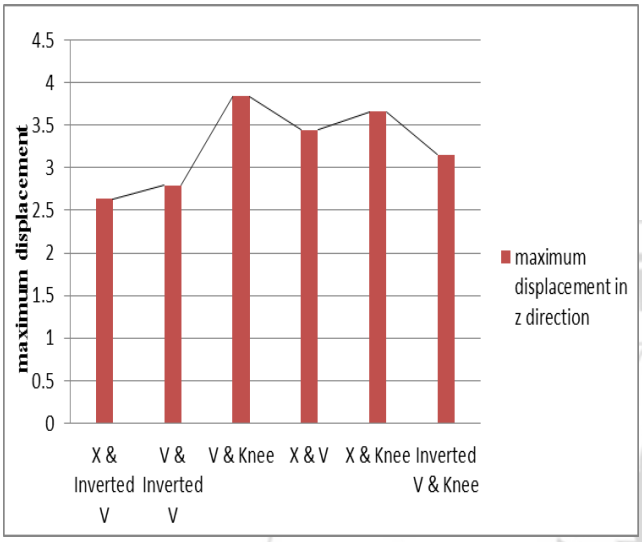

Figure 13: maximum displacement in Z direction

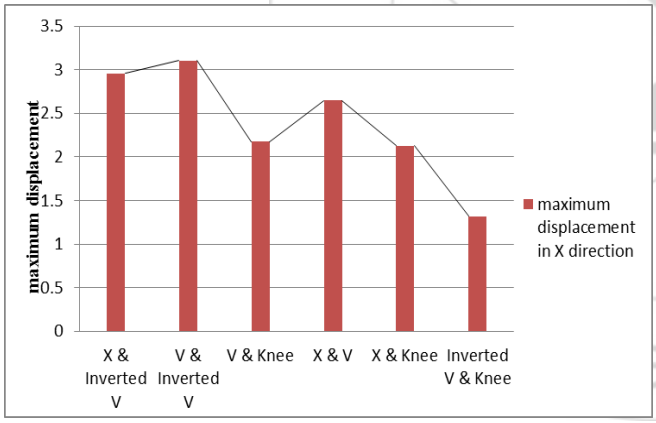

Figure 14: maximum displacement in X direction

The below figure shows the graph plotted for maximum storey drift along Z direction and maximum storey drift along X direction of different combination of bracing such as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing, X and Knee type, and Inverted V and Knee type bracing

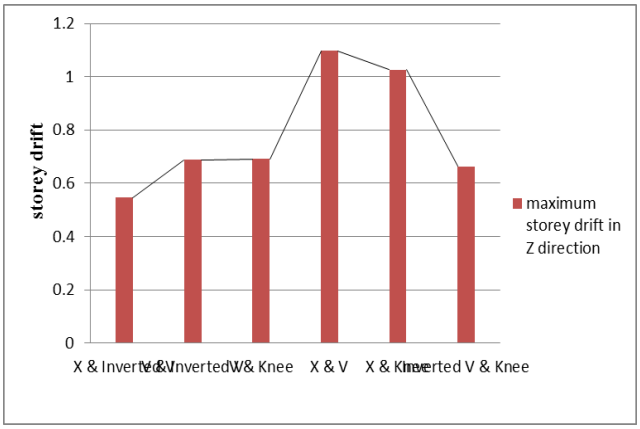

Figure 15: maximum storey drift in Z direction

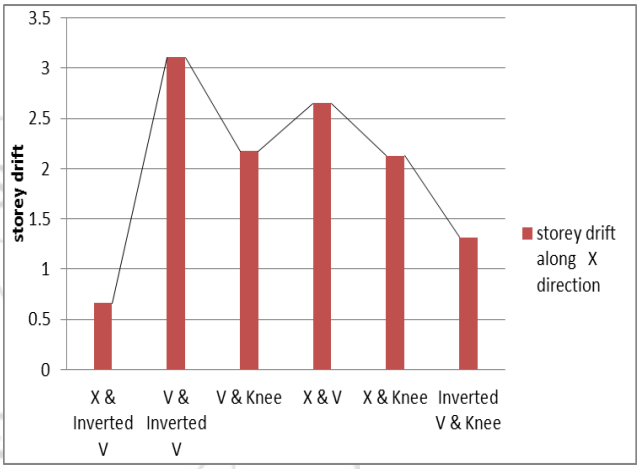

Figure 16: maximum storey drift in X direction

From above graph such as maximum displacement in Z direction, maximum displacement in X direction, maximum storey drifts in Z direction and maximum storey drifts in Z direction shows combination of x and inverted v bracing have lower value of maximum displacement in Z direction, and maximum storey drifts in Z direction and maximum storey drifts in Z direction. Displacement and storey drift of a building should be minimum for a effective building.

5. Conclusion

The effects of combination of bracing on seismic behaviour of six models of G + 4 steel structures with different Combination of bracing such as X and inverted V type bracing , X and V type bracing, V and inverted V type bracing, V and Knee type bracing, X and Knee type, and Inverted V and Knee type bracing were investigated. The results yield the following conclusions.

1) From validation roof displacement of different bracing such as such as X, V bracing, Inverted V type bracing, knee bracing were studied. From the study it is observed that the roof displacement of different types of bracing patterns is less as compared to steel bare frame.
2) Here X bracing have lower roof displacement than other bracing. Hence, X-bracing has shown effective results than any other bracing.
3) Comparing storey drift and displacement along both direction combination of x and inverted v bracing is more effective than any other combination of bracing in terms of average displacement and storey drift.

4) Comparing the maximum values of storey drift and displacement combination of x and inverted v bracing have lower value. That is combination of x and inverted v bracing is more effective than any other combination of bracing.

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