

# The Phenomenon of Internal Force Hedging After Two Trusses Overlapped With A Common Chord

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## Research Article

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# Abstract

Single truss structure is widely used in various fields of life, and has been very thorough researched. But for truss system, there are still many areas to be researched and developed. In this paper, through the mechanical test of two trusses overlapping, we find a mechanical phenomenon: the "internal force" hedging effect occurs when the two trusses share chord, but not when the chords are not shared.

## 1 Foreword

Truss is a plane structure composed of straight bars and generally has triangular elements, as shown in Fig. 1<sup>1,2</sup>. Truss members mainly bear axial tension or pressure<sup>3,4</sup>, so as to make full use of the strength of materials to give full play to the role of materials, save materials and reduce the weight of the structure<sup>5,6</sup>.

Truss structure originated in ancient Rome, after continuous development, it has been widely used in various fields of life, such as large space roof, Industrial workshop, bridge, aircraft, crane, and so on<sup>7</sup>. Therefore, the research of single truss has been very thorough and it has been widely used, but for truss system, there are still many areas to be researched and developed<sup>8</sup>.

After further research on the mechanical characteristics of truss, a mechanical phenomenon is found: When the two trusses are overlapped and loaded respectively, the lower chord of the upper truss generates tension and the upper chord of the lower truss generates pressure. If the upper and lower trusses are connected as a whole at the overlap, the "internal force" hedging effect will occur, so as to reduce the internal force of the structure; if the upper and lower trusses are only overlapped and do not form a whole, there is no such effect. This phenomenon is verified by experiments.

## 2 Experimental Verification

The phenomenon of internal force hedging is verified by truss loading test. The geometric dimension of single truss element is 3.2m×0.35m, the chord section is 60mm×30mm×3.5mm and the web member section is 30mm×30mm×3mm. The angle between web member and chord is 60°. Test scheme is shown in Fig. 2: ☒ One-layer truss; ☒ Two one-layer trusses are overlapped and do not share chords; ☒ Two one-layer trusses are overlapped and share chord, which forms a double-layer truss. The test content is to test the stress and deflection of chord (middle section of the member). The load is 3t per floor, which is vertically loaded in the middle of the span. Through the above tests, the stress and deformation characteristics of two trusses at the overlap are compared with one truss, and the "internal force" hedging phenomenon is studied.

The test results are shown in Table 1. The maximum stress of the upper and lower chords of one truss chord are -147.45MPa and 144.07MPa respectively, and the maximum deflection is -3.98mm; the stresses of the middle two chords of two trusses which do not share chords at the overlap are

133.45MPa and - 134.33MPa respectively, and the maximum deflection is -3.55mm; and the stress of the middle chord of double-layer truss at the overlap is -20.53MPa and the maximum deflection is -2.46mm.

It can be seen that the "internal force" hedging effect occurs when two one-layer trusses overlapped and share chord while the ones which do not share chords don't have such effect, and the stiffness of the former is much greater than that of the latter.

Table 1  
Test results

	Test point		Stress(MPa)			Deflection(mm)	
			1/4(right)	1/2	3/4(left)	1/4	1/2
One-layer truss	Top chord		-85.83	-147.45	-85.59	-2.56	-3.98
	Bottom chord		77.54	144.07	77.38	-2.55	-3.89
Two one-layer trusses overlapped and do not share chords	Upper truss	Top chord	-76.60	-143.66	-76.56	-2.25	-3.55
		Bottom chord	68.48	133.45	68.41	-2.26	-3.46
	Lower truss	Top chord	-70.39	-134.33	-70.19	-2.26	-3.46
		Bottom chord	77.77	144.46	77.58	-2.28	-3.56
Double-layer truss	Top chord		-80.95	-138.61	-80.93	-1.51	-2.45
	Shared chord		-10.82	-20.53	-10.79	-1.53	-2.39
	Bottom chord		82.02	139.34	82.02	-1.52	-2.46

### 3 Conclusion

When two trusses are overlapped and share a chord, the "internal force" hedging phenomenon happens. Based on the phenomenon, the frame structure can be reconstructed. For example, the three-layer frame can be connected by web members layer by layer to form a composite truss which can not only improve the bearing capacity, but also improve the stiffness. In addition, because the internal force is hedged, the materials used in the structure are relatively less. This phenomenon can be extended to the transformation of multi-layer frame structure and the structure with long cantilever. Therefore, the discovery of "internal force" hedging phenomenon has a far-reaching impact, which brings great application value for engineering, especially for multi-storey heavy load, large space and super long cantilever structure.

### Declarations

## Data Availability

The test data used to support the findings of this study are included within the article.

## Author contributions

The manuscript was drafted by Xiaoli Xie and completed in consultation with Xia Qin, Yuanzhong Xie, Chuangjie Yang, Chen Qiu.

## Author statements

Xiaoli Xie and Xia Qin wrote the main manuscript text, Yuanzhong Xie prepared all the figures and Chuangjie Yang and Chen Qiu did the experiment. All authors reviewed the manuscript.

## Conflicts of Interest

We have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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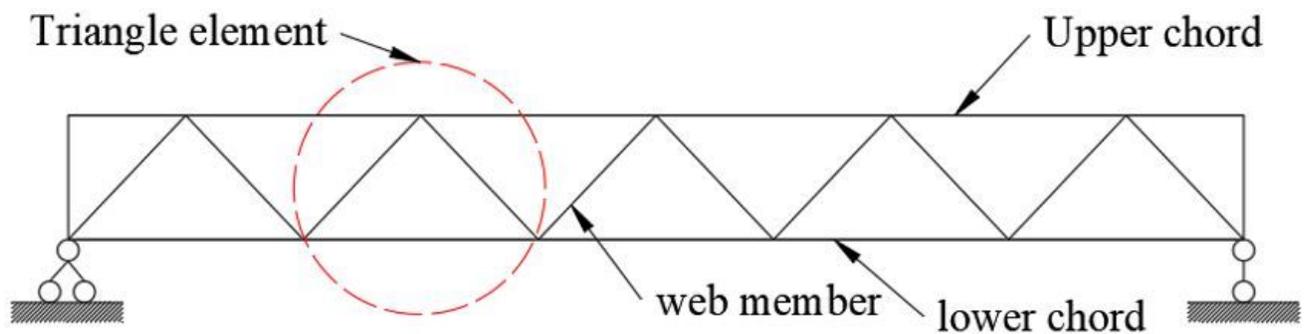
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## Figures



**Figure 1**

Schematic diagram of truss



**Figure 2**

Test scheme