"the deformeter is simple in design and can easily be fabricated,"

A Deformeter for Model Analysis of Structure—I*

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Introduction

The use of laboratory models for predicting the behavior of the prototype structures has been widely used. The following may be regarded as justifications for the use of such laboratory models:

(1) mathematical analysis of the problem is virtually impossible;
(2) theoretical analysis, though possible, is so complex and tedious that a model analysis offers an advantageous short cut;
(3) the importance of the problem is such that verification of the mathematical solution by model analysis is warranted.

The establishment of the science known as Model Analysis led to the development of many useful tools for the laboratory model analysis. Among such instruments are: the Beggs Deformeter, the Eney Deformeter, the Continostat, and others.

The Principle of the Deformeter Method

The deformeter is an apparatus for measuring deformation introduced into the laboratory model of the prototype structure. The application of the Muller-Breslau's Principle and Maxwell's Theorem of Reciprocal Deflections to the deformed model is the basis for predicting the behavior of the prototype structure. The basic deformeter relation is given by the equation:

$$X_a = K\ P_c \frac{\Delta_{ca}}{\Delta aa},$$ in which, from Fig. 1,

*Professorial Chair Paper in Structural Mechanics, U.P. Engineering Research and Development Foundation, Inc., 1981.

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X_a = the unknown force component acting at point "a" of the structure.

P_c = the force acting on the structure at point "c".

K = a constant dependent on the dimensions of the model. If X_a is an axial force or shear force component, K equals unity. If X_a is a moment, K is equal to the number of units of length of the structure represented by one unit on the model.

Δ_{aa} = displacement introduced in the model at point "a" in the direction of the force component X_a.

Δ_{ca} = the deflection of the load point "c" in the model measured parallel to the line of action of the force P caused by the induced displacement Δ_{aa}.

Using the above equation the unknown force component acting on the structure can be found by determining on the model the ratio of the deflection of the point corresponding to the point of load on the structure, measured parallel to the line of action of that load, to the displacement induced in the model along the line of action of the unknown force component.

Description of the Deformeter

The apparatus presented here is a very simple type of deformeter and the model used is a brass wire 1/8" in diameter. Figure 2 is a photograph of the set up. The load point in the model is shown with a plastic clamp attached. A close-up photograph of this plastic clamp is shown in Figure 3. At the bottom of this plastic clamp there is attached a metal needle located directly below the load point in the model. Deflection of this load point may be measured by means of pricks made by the needle on a piece of paper taped to the wooden base of the apparatus. Figure 4 shows the clamping device for holding the model and provision for inducing the displacements at the supports (horizontal and vertical displacements, and rotation).

Model Analysis of One-Story Bent

A theoretical analysis of the reaction components at both fixed ends of the one-story rigid frame loaded as shown in Figure 5 was made. For simplicity all members of this frame have the same cross-sectional dimensions (uniform I). Using the principles of similitude the dimensions of the brass wire model of the structure were determined and the model was fabricated accordingly. The following length scale was used: 2' (prototype) = 1" (model). Since the structure has a uniform I the brass wire used had a constant diameter (1/8") throughout. All deflections/displacements and rotations were measured by an ordinary ruler graduated in millimeters.

The results of the model test, as compared with theoretical values, are tabulated below:

	Right Support (Fixed-End)		Left Support (Fixed-End)	
	Experimental	*Theoretical*	*Experimental*	*Theoretical*
Thrust	9.85 kips	10.11 kips	5.85 kips	5.89 kips
Shear	1.23 kips	1.36 kips	1.54 kips	1.36 kips
Moment	13.73 ft-kips	8.17 ft-kips	13.33 ft-kips	9.77 ft-kips

The values of the thrusts and shears at the supports as determined from the model test do not differ greatly from the theoretical analysis. However, the moments differ very much from the theoretical values. This may be explained by the not-too-refined technique employed in the measurement of rotations in the model. Likewise it should be noted that the design of the clamping device for holding the model allows tests simulating fixed supports only. This deformeter cannot give accurate results on model tests for prototype structures with hinged supports.

Observations

1. Within a limited scope this deformeter may be used for checking theoretical analysis of statically indeterminate structures.
2. This apparatus could be useful for demonstrating principles of similitude applied to structures.
3. The deformeter is simple in design and can be easily fabricated.
4. An improved design of the apparatus is most desirable and should include provisions for:
   (a) more accurate measurement of induced rotations in the model;
   (b) model testing of structures with either hinged or fixed supports.

References

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2. Wilbur, John B. & Norris C. H., "Elementary Structural Analysis", p. 356; p. 450; McGraw-Hill Book Co., 1948.
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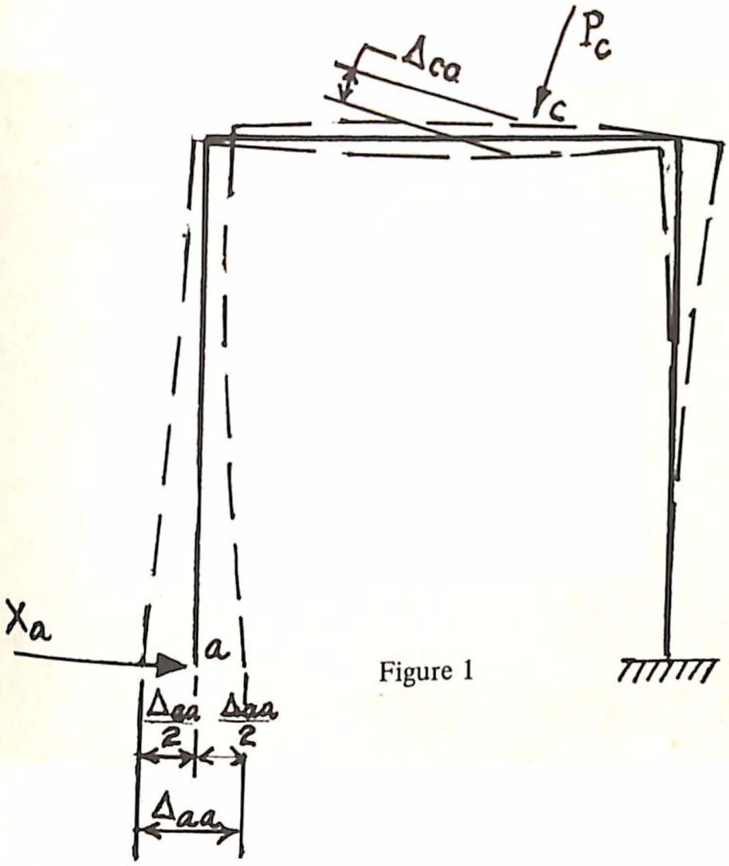

Figure 1

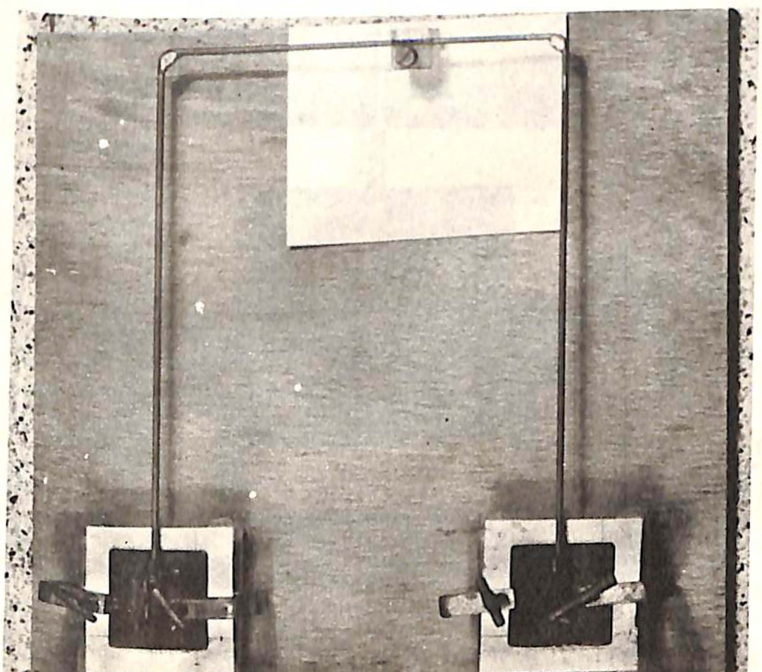

Figure 2

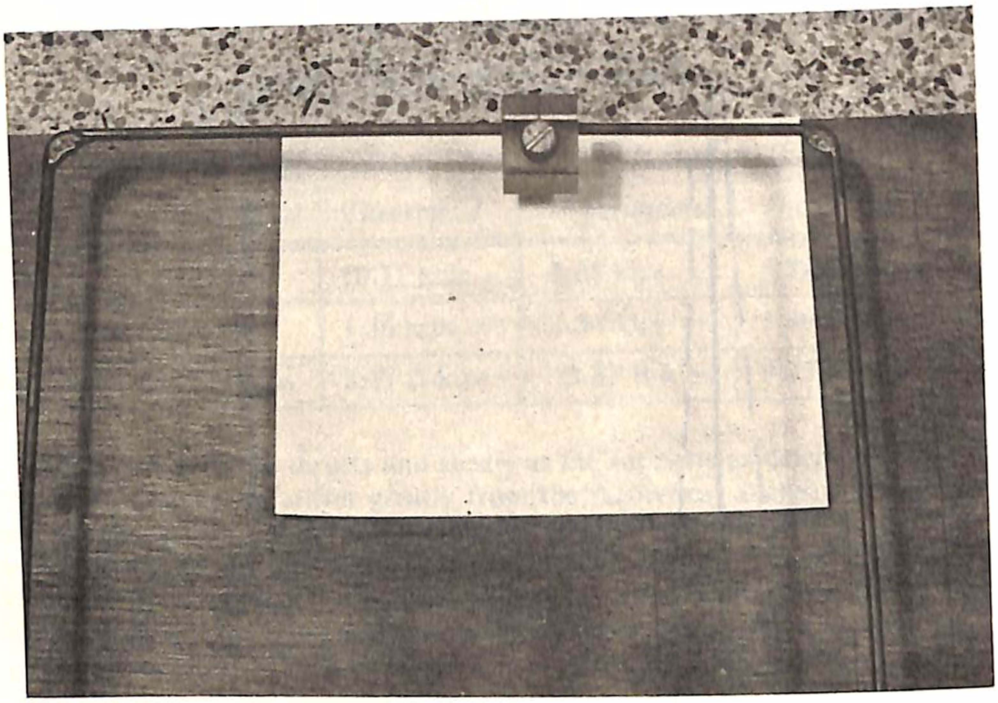

Figure 3

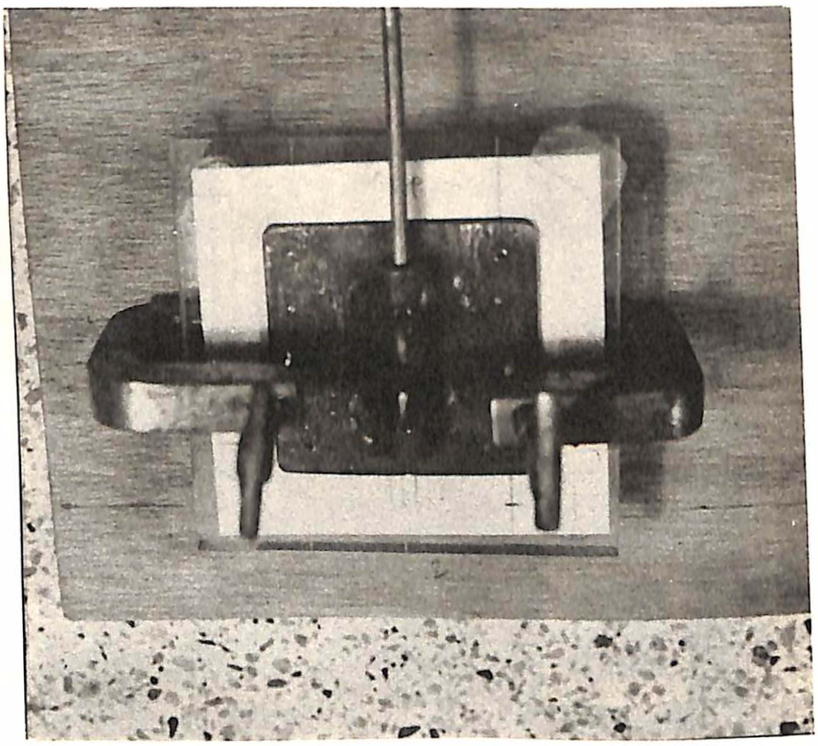

Figure 4

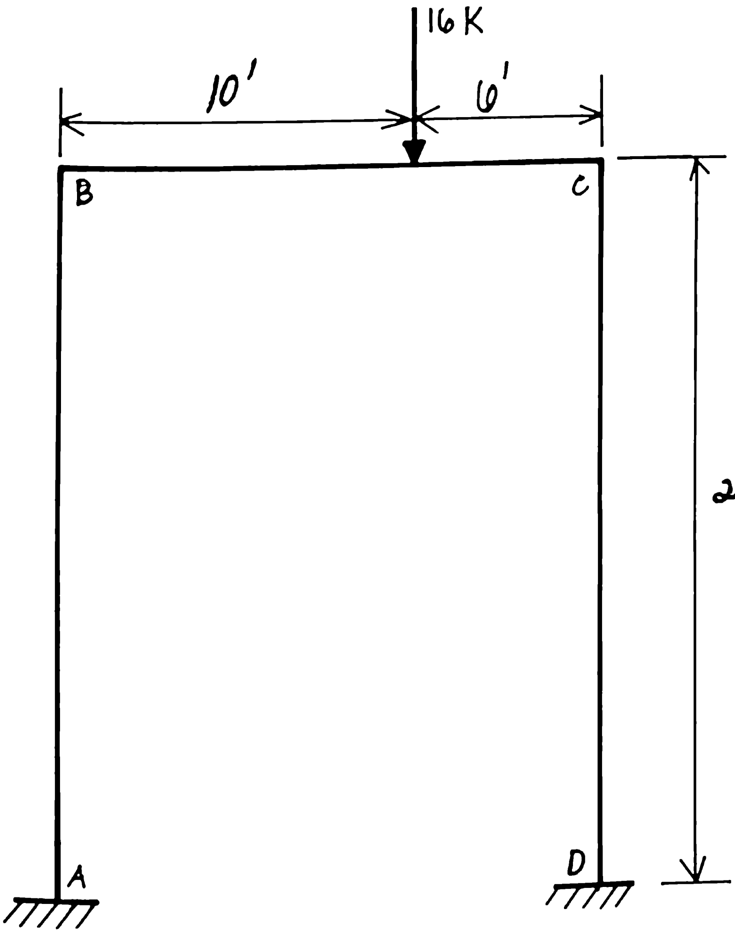

FIGURE 5

Reaction Components (Theoretical):

X_A = 1.36 kips →
Y_A = 5.89 kips ↑
M_A = 9.77 ft-kips ↻

X_D = 1.36 kips ←
Y_D = 10.11 kips ↑
M_D = 8.17 ft-kips ↺