NOMENCLATURE FOR COMPOSITE STEEL
AND CONCRETE BEAMS

Report to ASCE-ACI Committee on Composite Construction
Subcommittee III--Terminology of Composite Construction

Prepared by
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This report gives preliminary suggestions for a list of nomenclature for composite beams consisting of a steel beam supporting a concrete slab with some sort of shear connection supplied to transmit shear between the steel and concrete sections. The list is intended to cover those properties which are common to all composite beams of this type. There are undoubtedly additional properties arising in individual designs which might have been included in this list. However, for brevity many of these are omitted.

Wherever possible the usages of the American Concrete Institute\(^1\) have been followed in this report when considering concrete. Terms used by the American Institute of Steel Construction\(^4,5,8\) have been used where steel alone is concerned. Because of its reasonably complete coverage of the subject of composite beams there is also much nomenclature taken from the specification of the American Association of State Highway Officials. In this list an attempt has been made to set up a nomenclature which does not clash too seriously
with either of the existing basic systems but which will allow nomenclature to be handled effectively when both materials are used together as in composite beams.

The list has been broken into five (5) basic sections:

1. Geometric properties of members
2. Physical properties of materials
3. Loads, forces, stresses and moments
4. Geometric terms used in stress analysis
5. Terms related to shear connectors

Within these basic sections wherever applicable, separate lists are shown for the steel and the concrete nomenclature. In some cases also nomenclature referring to the complete composite beam is listed separately. Following each entry in the nomenclature is a reference number referring to the list of references and designating the reference from which the specific term was selected. Also, accompanying each definition is a designation of the units in which this term would be expressed. These units are designated by expressions "F" for force and "L" for length.

This list of nomenclature is suggested as a basis for the committee to begin its preparation of a more complete list. It is probable that once the complete list is agreed upon it would also be worthwhile to make a single list in alphabetical order to enable individual symbols to be located more quickly.
NOMENCLATURE

I. Geometric Properties of Members

Steel Beam

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_b$</td>
<td>area of bottom flange of steel member $^7$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$A_p$</td>
<td>area of cover plate $^7$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$A_s$</td>
<td>total area of steel member $^1$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$A_t$</td>
<td>area of top flange of steel member $^7$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$A_w$</td>
<td>area of web of steel member $^7$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$d$</td>
<td>depth of steel member $^4$</td>
<td>$(L)$</td>
</tr>
</tbody>
</table>

Concrete Slab

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_c$</td>
<td>transformed area of concrete slab $^3$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$A_s^i$</td>
<td>area of steel slab reinforcement $^1$</td>
<td>$(L^2)$</td>
</tr>
<tr>
<td>$b$</td>
<td>width of concrete slab $^2$</td>
<td>$(L)$</td>
</tr>
</tbody>
</table>

Composite Beam

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_c$</td>
<td>depth of composite section $^0$</td>
<td>$(L)$</td>
</tr>
<tr>
<td>$L$</td>
<td>span length center to center of bearing $^1$</td>
<td>$(L)$</td>
</tr>
</tbody>
</table>

II. Physical Properties of Materials

Concrete

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_c$</td>
<td>modulus of elasticity of concrete $^1$</td>
<td>$(F/L^2)$</td>
</tr>
<tr>
<td>$f'_c$</td>
<td>compressive strength of concrete at age 28 days $^1$</td>
<td>$(F/L^2)$</td>
</tr>
</tbody>
</table>

Steel

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E)</td>
<td>$E_s$ = modulus of elasticity of steel $^1$</td>
<td>$(F/L^2)$</td>
</tr>
<tr>
<td>(F_y)</td>
<td>$f_y$ = yield stress of steel member $^5$</td>
<td>$(F/L^2)$</td>
</tr>
</tbody>
</table>

$n$ = ratio $E_s$ divided by $E_c$ $^2$  \( (-) \)
III. **Loads, Forces, Stresses and Moments**

\[ C = \text{total compressive force in the concrete slab} \] (F)

\[ C_s = \text{total compressive force in the steel member} \] (F)

\[ f_c = \text{stress in concrete} \] (F/L^2)

\[ f_s = \text{stress in steel} \] (F/L^2)

\[ M_D = \text{moment due to dead load which is applied before concrete reaches 75\% of } f_c \] (FL)

\[ M_L = \text{moment due to live load and superimposed dead load} \] (FL)

\[ M_p = \text{plastic moment of the steel member} \] (FL)

\[ M_u = \text{ultimate moment of composite section} \] (FL)

\[ T = \text{total tensile force} \] (F)

\[ v = \text{horizontal shear force per unit length of beam} \] (F/L)

\[ V = \text{total shear force} \] (F)

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IV. **Geometric Terms used in Stress Analysis**

\[ a = \text{depth of compressive stress block at ultimate moment} \] (L)

\[ e = \text{distance between resultant compressive and tension forces at ultimate moment} \] (L)

\[ I = \text{moment of inertia of steel section} \] (L^4)

\[ I_c = \text{moment of inertia of composite section} \] (L^4)

\[ L_s = \text{distance between sections at which ultimate moment and zero moment occur} \] (L)
Q = static moment of transformed concrete area about the neutral axis of the composite member $^2$ (L$^3$)

($S_g$) $S =$ section modulus of steel beam $^4$ (L$^3$)

$S_b =$ section modulus of composite section referred to bottom $^0$

$S_t =$ section modulus of composite section referred to top of concrete slab $^0$

$y_b =$ distance from neutral axis of composite section to bottom of steel section $^0$ (L)

$y_t =$ distance from neutral axis of composite section to top of concrete slab $^0$ (L)

$Z =$ plastic modulus of steel section $^5$ (L$^3$)

$Z_c =$ plastic modulus of composite section $^0$ (L$^3$)

V. Terms Related to Shear Connectors

d$g =$ diameter of shear connector stud or spiral $^2$ (L)

$f'_{sg} =$ ultimate strength of shear connector material (F/L$^2$)

($t_f$) $h =$ maximum flange thickness of channel shear connector $^2$ (L)

$H =$ height of stud shear connectors $^0$ (L)

$q =$ resistance value of one shear connector at working load $^2$ (F)

$q_u =$ ultimate strength of one shear connector $^0$ (F)
Units

\[ s = \text{spacing of shear connectors}^2 \quad (L) \]
\[ t = \text{web thickness of channel shear connector}^2 \quad (L) \]
\[ w = \text{length of channel shear connector}^2 \quad (L) \]

Symbols in parentheses refer to corresponding symbol used in the 1961 AISC Specifications if different than the symbol selected here.

Numerals following each definition refer to the reference number from the list of references.
REFERENCES

0. Symbol suggested by Lehigh University

1. ACI
   AMERICAN CONCRETE INSTITUTE BUILDING CODE, American Concrete Institute, ACI 318-56, Detroit (1956)

2. ASCE-ACI
   TENTATIVE RECOMMENDATIONS FOR THE DESIGN AND CONSTRUCTION OF COMPOSITE BEAMS AND GIR德ERS FOR BUILDINGS, Journal, Structural Division, ASCE, Vol. 86, No. ST12, December 1960

3. Culver, C., and Coston, R.
   TESTS OF COMPOSITE BEAMS WITH STUD SHEAR CONNECTORS, Fritz Laboratory Report, No. 354.1 (1959)

4. AISC
   STEEL CONSTRUCTION MANUAL, American Institute of Steel Construction, New York (1947)

5. AISC
   PLASTIC DESIGN IN STEEL, American Institute of Steel Construction, New York (1959)

6. Beedle, L. S.
   PLASTIC DESIGN OF STEEL FRAMES, John Wiley and Sons, New York (1958)

7. Viest, I. M., Fountain, R. S., and Singleton, R. C.

8. AISC
   SPECIFICATION FOR THE DESIGN, FABRICATION & ERECTION OF STRUCTURAL STEEL FOR BUILDINGS, American Institute of Steel Construction, New York (1961)
March 7, 1962

Mr. A. M. Lount
Lount and Associates
164 Eglinton Avenue, E.
Toronto 12, Canada

Dear Mr. Lount:

In answer to your letter of February 6, 1962, I am transmitting to you a brief report suggesting nomenclature for composite steel and concrete beams. This report is also transmitted to the other members of the subcommittee on nomenclature. I hope it may serve as a jumping off point from which to begin preparation of the complete nomenclature. I will now await your suggestions to myself and the other members of the subcommittee as to further action to be taken on this suggested nomenclature.

Sincerely yours,

George C. Driscoll, Jr.

GCD:Im

Encl.

cc: Messrs. I. A. Benjamin
    N. W. Hanson
    P. Page, Jr.
    T. R. Higgins