A MICROCOMPUTER PROGRAM FOR THE DESIGN OF COMPOSITE BEAMS

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd.)

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

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1. INTRODUCTION

1.1 General

Composite construction generally consists of combining two or more materials in one structural unit, and using each material to its best advantage. The most common type of composite construction in buildings involves steel floor beams and a concrete floor slab acting together as a unit due to the action of shear connectors welded to the top flanges of the steel beams. An important factor in composite action is that the bond between concrete and steel remains unbroken.

Composite construction is of particular advantage economically when loads are heavy, spans are long and beams are spaced at fairly large intervals. It can often support a one-third or even greater increase in load than could the steel beams in noncomposite action.

1.2 Objective and Scope

The objective of this thesis is to write a computer program to design composite beams as unshored with the following variables:

1.2.1 MATERIALS

a. Concrete

Ultimate concrete strength up to 8000 psi

b. Steel

Steel yield strength may be 36 or 50 ksi

1.2.2 LOADS

Loads on the beam may be

a. uniformly distributed load only

b. concentrated loads only

c. both uniformly distributed and concentrated loads

1.2.3 SLAB

Slab may be

a. solid slab

b. slab on formed steel deck parallel to the beam

c. slab on formed steel deck perpendicular to the beam

1.2.4 BEAM

The program may

a. design the most economical section

b. review a specific standard section

c. review a built-up section

d. design for depth restriction using wide beams and coverplate if necessary.

1.2.5 SHEAR CONNECTORS

Headed studs are used with different capacities according to stud diameter and concrete strength, so that full composite action is attained.

2. FUNDAMENTALS AND OVERVIEW

2.1 HISTORICAL DEVELOPMENT

The composite beam began with the use of fireproofing systems for floors. In the early part of the twentieth century several studies in different parts of the world spurred the development of the composite beam. The first study was made in 1927 by Mackay et al (3), which dealt with encasement of steel beams in concrete. In 1929 Cauphey and Scott (5) collaborated on a paper that dealt with the design of a steel beam and concrete slab. They pointed out the need for mechanical shear connectors to carry the horizontal shear. By the 1930's, composite construction had become known almost world-wide. In 1944 the American Institute of Steel Construction included provisions for composite construction for buildings in its Specification (2). The first approval for composite building floors was given by the 1952 AISC Specification (2), and today they are widely used.

2.2 COMPOSITE ACTION

Composite action is developed when two load carrying structural members, such as a concrete floor system and the supporting steel beams, are integrally connected and deflect as a single unit. A typical example of a composite cross section is shown in Fig. 2.1. The extent to which composite action is developed depends on the provisions made to insure a linear strain distribution from the top of the concrete slab to the bottom of the steel section. To understand the concept of composite behavior, consider first the noncomposite beam of Fig. 2.2.a, wherein, if friction between the slab and beam is neglected, the beam and slab each carry separately a part of the load. When the slab deforms under vertical load, its lower surface is in tension and elongates, while the upper surface of the beam is in compression and shortens. Thus, a discontinuity will occur at the plane of contact. Since friction is neglected, only vertical internal forces act between the slab and beam.

When a system acts compositely [Fig. 2.2.b], no relative slippage occurs between the slab and beam. Horizontal shear forces are developed, which, when acting on the lower surface of the slab compress and shorten it, while those acting on the upper surface of the beam elongate it. By an examination of the strain distribution that occurs when there is no interaction between the concrete slab and the steel beam [Fig. 2.3.a], it is seen that the total resisting moment is equal to

$$M = M\ \text{slab} + M\ \text{beam}$$

It is noted that for this case there are two neutral axis: one at the center of gravity of the beam and the other at the center of gravity of the slab. Horizontal slippage results from the bottom of the slab being in tension and the top of the beam being in compression.

Consider next the case [Fig. 2.3.b] where only partial interaction is present. The neutral axis of the slab is closer to the beam, and that of the beam closer to the slab. Due to the partial interaction, the horizontal slippage has now decreased. The result of the partial interaction is the partial development of the compressive and tensile forces, C' and T', which are less than the maximum capacities of the concrete slab and steel beam, C" and T" respectively. The resisting moment of the section is now increased by the amount T' e' or C' e'.

When complete interaction between the slab and the beam is developed, no slippage occurs; the resulting strain diagram is shown in Fig. 2.3.c. Under this condition, a single neutral axis exists that lies below that of the slab centroid and above that of the beam centroid. In addition, the compressive and tensile force C" and T" are larger than the C' and T' existing with partial interaction. The resisting moment of the fully developed section then becomes

$$M = T'' e'' \text{ or } C'' e''$$

2.3 COMPARISON OF COMPOSITE AND NONCOMPOSITE CONSTRUCTION

Composite construction became generally accepted by engineers for buildings in the 1960's. It led to greater economy due to the increased stiffness due to the composite action. Lateral buckling of the compression flange is eliminated by connecting the steel beam to the concrete slab with shear connectors. It also is particularly competitive in long span structures, and where there are economic advantages resulting from rapid construction.

The structural advantages of composite vs. noncomposite construction may thus be summarized as follows:

1. The depth of the steel beam required to support a given load is reduced.
2. An increase in the capacity is obtained over that of a noncomposite beam, on a static ultimate load basis. Tests have shown that the ability of composite structures to take overload is greater than for noncomposite structures.
3. For a given live load, a reduction in a composite structure's dead loads and construction depth reduces in turn the story heights, foundation cost, paneling of exteriors, and heating, ventilation, and air-conditioning spaces, thus reducing the overall cost of a building.

4. Deflection of composite beams is about 1/3 to 1/2 less than that of noncomposite beams due to the increased stiffness associated with the composite action.

2.4 SHEAR CONNECTORS

2.4.1 IMPORTANCE OF SHEAR CONNECTORS IN COMPOSITE CONSTRUCTION

Composite action of a steel beam and a concrete slab implies interaction between them and a transfer of shear at their connection. In the common type of composite beam, there is some shear transfer by bond and friction at the interface between steel beam and concrete slab. This cannot be depended upon if there is a single overload or pulsating load that will destroy such bond and cause a separation of the slab from the beam. Hence, shear connectors are needed to give reliable composite action with two objectives:

1. To transfer shear between the steel and the concrete, thus limiting the slip at the interface so that the slab-beam system acts as a unit to resist longitudinal bending.
2. To prevent an uplift of the slab relative to the beam, i.e., to prevent separation of the steel and the concrete at right angles to their interface.

2.4.2 CONNECTOR DESIGN

Under loads a horizontal shear between the concrete slab and the beam is developed. This shear must be resisted by the shear connectors so that the composite section acts monolithically. Ideally the shear connector should be stiff enough to provide complete interaction. Referring to the shear diagram of a uniformly loaded beam in Fig. 2.4, the shear force varies from zero at mid-span to maximum at the support. It can be inferred that more shear connectors would be required near the ends of the span than at the mid-span. Consider the shear-stress distribution of Fig. 2.5 wherein the stress v_1 must be developed by the connection between the slab and the beam under service load. The shear force per unit distance along the span is

$$v_1 b_e = VQ/I_{tr} \tag{2.1}$$

where:

V = vertical shear force

I_{tr} = transformed moment of inertia

Q = static moment of the effective concrete area about the centroid of the composite section

b_e = slab effective width divided by the modular ratio, n.

Thus if a given connector has an allowable capacity q, the maximum spacing p to provide the required capacity is

$$p = q/(VQ/I_{tr}) \tag{2.2}$$

2.4.3 TYPES OF SHEAR CONNECTORS

Various types of shear connectors have been used to resist longitudinal shear and uplift. Connectors may be divided into two categories, rigid and flexible. It must be pointed out that slip must occur before the connectors are utilized, therefore, the terms are relative. The rigid type are the barlike heavy connectors (Fig. 2.6.a). The flexible ones are the stud and channel type of connectors (Fig. 2.6.b). The rigid-bar or channel connectors are limited to shear transfer in one direction only, while the welded stud connectors can resist and transfer shear in any direction perpendicular to the shank, making them a more useful connector.

2.5 SHORING

The actual stresses that are developed in a composite member due to a given loading are dependent upon the manner of construction. The simplest construction occurs when the steel beams are placed first and used to support the concrete slab form-work. In this case, the steel beam acting noncompositely, i.e. by itself, supports the weight of the forms, the wet concrete, and its own weight. Once forms are removed and concrete has cured, the section will act compositely to resist all dead and live loads placed after the curing of concrete. Such construction is said to be without temporary shoring, or unshored. Alternatively, to reduce the service load stresses, the steel beam may be supported on temporary shoring, in which case the steel beam, forms, and wet concrete are carried by the shores. After curing of the concrete, the shores are removed, and the section acts compositely to resist all loads. This system is called shored construction. At working loads there are initially different stress distributions in shored and unshored beams. These are shown in Fig. 2.7. Assuming equal loads, the slab stresses in the shored beam are higher and the steel stresses are lower than in the unshored beam. However, in the shored beam the slab carries the dead load stresses which are long-term effects, so that dead load creep acts to change this pattern. The effect of creep and stress relaxation is to shift stresses out of the slab into the beam, so that in the long term, the stress patterns for the shored and unshored cases are very nearly equal. Shored construction does provide a smaller steel section. However, the additional cost of shoring usually nullifies its advantages. So the practical question is, "should the beam be shored or not?" Probably the answer is "No". The usual decision is to use heavier steel beams and do without shoring for several reasons:

1 - Apart from reasons of economy, the use of shoring is a tricky operation, particularly where settlements of the shoring are possible.

2 - Tests have shown that the ultimate strengths of composite sections of the same sizes are the same whether shoring is used or not. Therefore, if lighter steel beams are selected for a particular span because shoring is used, the result is smaller ultimate strength.

If the beam is to be shored, the engineer must set the falsework carefully to maintain the proper slab thickness. The slab must act as a top coverplate for the beam, so its thickness is important. If the shores are forced in too tightly at mid-span, giving the beam an upward deflection, the slab may be thinner than the design slab. On the other hand, if the beam is not to be shored, the engineer should check the deflection of the steel beam, under the dead load of formwork, wet concrete, rebars, and men and equipment placing the concrete. It is possible under those temporary construction loads to get an excessive mid-span deflection, which means that more concrete must be added to bring the slab up to grade. This is added dead load, and a slab results which is thicker than the design at the section of maximum positive bending moment.

2.6 EFFECTIVE WIDTH OF SLAB

In the case of a beam with a wide flange relative to its depth, the web causes the bending stresses in the flange to vary from a maximum at the top of the web to a minimum at the flange tips because of shear lag. Fig. 2.8 shows the nonuniform longitudinal stress distribution across the top of the flange of a composite beam. Generally the stress distribution varies from section to section along the span, and is not only a function of the relative dimensions, stiffnesses of the components of composite structural system, boundary conditions, and structural behavior (elastic deformation, non-linear elastic creep, shrinkage, temperature effects, etc.), but also depends on the nature and distribution of the applied loads. Because of their complexity, the theoretical solutions that are available are too cumbersome to be used in design.

The effective width used in design is defined as that width of slab that, when acted on by the actual maximum stress, would have the same static equilibrium effect as the existing variable stress. Traditionally, the effective width is based on stress distribution along the span and width of the top flange. The effective width of a flange for a composite member can be taken as $b = b_f + 2b'$ (Fig. 2.8), where $2b'$ times the maximum stress, $(\sigma_x)_{max}$, is equal to the area under the curves for σ_x. The total compression carried by the equivalent system is the same as that carried by the actual system. The value of b' depends on the span length and type of loading. According to Johnson (5), for loading that produces bending moment having a half-sine wave shape, the effective width is

$$b = b_f + \frac{2L}{U(3 + 2U - U^2)} \qquad (2.5)$$

where:

L = span length of beam

b_f = steel beam flange width

U = Poisson's ratio for the slab

assuming: $U = .2$ for concrete

$$b = b_f + 0.19L \qquad (2.6)$$

As a simplification for design purposes, the American Institute of Steel Construction (AISC) (2), and the American Concrete Institute Building Code (ACI 1977)(1), have adopted the same method of computing effective flange width. In these specifications the maximum value of the effective width b is computed according to the following relations, whichever is smaller:

1. For an interior girder with slab extending on both sides of the girder:

   a. $b = L/4$ (2.3.a)

   b. $b = s$ (2.3.b)

   c. $b = b_f + 16t$ (2.3.c)

2. For an exterior girder with slab extending only on one side:

   a. $b = L/12 + b_f$ (2.4.a)

   b. $b = (s + b_f)/2$ (2.4.b)

   c. $b = b_f + 6t$ (2.4.c)

   where:

   L is the beam length

   s is the beam spacing

   b_f is the width of beam flange

   t is the thickness of the slab

2.7 SECTION PROPERTIES

The section properties of a composite section can be computed by the transformed area method. In contrast to reinforced concrete design, where the steel area is transformed into an equivalent concrete area, the concrete is transformed into equivalent steel. As a result, the concrete is reduced by using a slab width equal to b/n, where n is the ratio of steel modulus of elasticity, E, to concrete modulus of elasticity, E_c. The modulus of elasticity of concrete in psi is generally taken as (1)

$$E_c = 33\ w^{1.5} \sqrt{f'_c} \tag{2.7}$$

where w is weight of concrete in pcf, and f'_c is in psi units.

Values of the concrete modulus of elasticity and the modular ratio for various concrete strengths are listed in Table (2.1). The minimum value for n permitted by the ACI code (1) is 6. The composite section may be considered as a steel member to which a cover plate has been added on the top flange. This cover, being concrete, is considered to be effective only when the top flange is in compression.

Table (2.1) Values of Modulus of Elasticity and Modular Ratio for Normal Weight Concrete

Concrete Strength (f'_c psi)	E_c(ksi)	Modular Ratio ($n = E/E_c$)
3000	3150	9
3500	3400	8.5
4000	3640	8
4500	3860	7.5
5000	4070	7
6000	4695	6.5

2.8 COVER PLATES

Coverplating of beams is often used in composite construction. In many cases of a symmetrical beam with a slab, the neutral axis of the composite beam falls within the slab. This is not the most efficient use of material because only part of the slab is acting in compression. The addition of a lower flange coverplate tends to move the neutral axis downward, usually to a point below the slab.

Cost figures must be checked carefully at this point. In a building with uniformly distributed loads, plates can be cut off when they are no longer needed. The coverplate length is usually about 60 to 70% of the beam span length. On this basis, adding a coverplate may save 20% of steel weight when compared to the alternative of using a larger symmetrical section. This savings in weight must be balanced against the cost of fabricating the coverplated beam. It costs virtually the same to weld on a thick plate as a thin one. So a general rule might be to use a fairly thick coverplate or none at all.

AISC (2) recommends that if the coverplated section saves less than 7 lbs/ft., a coverplate should not be used. If the coverplated section saves more than 12 lbs/ft., use a coverplate. Between these limits plates may or may not be economical depending on local fabricating costs. However, in some cases the use of a coverplate is necessary, because of depth restrictions, to keep the depth within certain limits.

The theoretical cut-off point for coverplates can be determined either mathematically or graphically. The plate must extend beyond the theoretical point, and the extended portion must be attached with enough bolts or weld material to develop the full strength of the plate. For a uniformly distributed load the moment diagram is a simple parabola (Fig. 2.9). The cut-off point, x, is determined from the following ratio:

$$x^2/(L/2)^2 = b/y \tag{2.8}$$

Graphically, the moment diagram can be accurately laid out to scale. The resisting moment of the section with coverplate can be superimposed on the same drawing. The cut-off point is the point at which the resisting moment of the uncoverplated section, M_R, intersects the moment diagram. The method is illustrated in Fig. 2.10. For beams loaded with concentrated loads, the bending moment may be calculated at suitable intervals, say 1/2 ft. or 1/4 ft. Then the coverplate should extend over the length of the beam where the bending moment exceeds the resisting moment, M_R, of the beam without the coverplate.

2.9 LATERAL SUPPORT

In ordinary steel beam design, the compression flange must be given adequate support in order to prevent lateral buckling. If lateral support is not provided, a reduced value of allowable stress must be used (2).

In composite construction, the slab that is attached to the beam furnishes this support. However, this lateral support is not effective until the slab has achieved 75% of its required strength. So lateral buckling of the compression flange should be checked under the effect of the steel beam weight, plus weight of the concrete and any superimposed load that is present during construction.

In unshored construction in which the forms are supported by the steel beams, ordinary formwork does not provide adequate lateral support. The formwork should be designed to provide positive support for the compression flange if it is required.

In the case of composite beams with metal deck, the metal deck provides lateral support for the compression flange if the ribs or corrugations run perpendicular to the length of the beam.

2.10 COMPOSITE STEEL BEAMS WITH METAL DECK

Light-gauge, steel-concrete composite floor systems are in common use. Generally such systems consist of a concrete slab on some type of cold-formed corrugated and/or ribbed decking. When composite construction is used, the use of metal deck is commonly considered. There are, however, other uses for the deck: (1) form for wet concrete; (2) working platform during construction; (3) diaphragm for the transfer of lateral loads; and (4) part of a composite beam system.

The advantages of combining the structural properties of cold-formed, light-gauge steel deck and concrete for use in floor systems for building were recognized many years ago. The most significant advantage was the reduced cost of the structure and foundations. Furthermore, the use of the deck, both as a platform for construction operations and as a form for the concrete, replaced the expensive conventional forming systems used previously. The deck also has potential in channeling electrical and communications wiring through cellular construction. The steel ceiling formed by the underside of the deck facilitates the attachment of hanger supports for piping, ductwork, and suspended ceilings. Also, since the metal deck acts as the form for the wet concrete and generally does not require shoring, the time of construction for a structure may be reduced since each floor is independent and one need not wait for concrete to gain strength to support superimposed shoring as in cast-in-place systems. In addition, time is not required to remove shoring. The use of steel deck is accompanied by a nominal amount of temperature and shrinkage reinforcement, and the deck itself serves as the positive reinforcement once the concrete has hardened.

In order to present an unbiased treatment of the subject, it is reasonable to discuss the disadvantages, which, other than the extra cost of the deck, are mainly centered on the characteristics of the decking. To insure good bond, the deck requires cleaning prior to placing concrete. Furthermore, oil and water create a slippery and potentially dangerous working surface. Finally, the advantage of the availability of the deck to act as a working platform can become a disadvantage if the deck is damaged by temporary storage of heavy concentrated loads.

The metal deck can be oriented either parallel or perpendicular to the steel beam. The behavior of composite beams is directly applicable to composite-beam-metal-deck systems with a few exceptions. These exceptions are:

1. The effective slab thickness of the composite system is normally calculated based on the total depth of the solid portion of the concrete and the ribs.
2. The capacity of the shear connectors is influenced by the geometry of the metal deck. In the case of metal deck spanning parallel to the composite beam, a reduction in shear connector capacity is required; also, shear connector capacities may be less than their maximum strength when the metal deck is spanning perpendicular to the composite beams.

2.11 DEFLECTION

The composite beam is generally much stiffer than its noncomposite counterpart, so that for equal spans, the deflection of a composite beam is 1/2 to 1/3 less than that of a noncomposite beam.

The deflection of a composite steel-concrete beam consists of three parts: (1) short-term dead load, (2) long-term creep and shrinkage, and (3) short-term live load. It is calculated using composite properties (transformed section) of steel and concrete and using a modular ratio, $n = E/E_C$.

In order to accurately determine the deflections of composite members, a number of factors must be taken into account that are not normally considered. These are: the method of construction, the separation of the live-load and dead-load moments, and the effect of creep and shrinkage in the concrete slab.

Limits on deflections are not well defined (8). Some engineers limit live-load deflection to L/360 for both shored and unshored construction. A well-defined limit on dead-load deflection for unshored construction does not exist. So some engineers limit the dead-load deflection to 1 inch so as to prevent a ponding problem on the unshored steel beam during the placing of the concrete.

If the construction is without shoring, the total deflection will be the sum of the dead load deflection of the steel beam and the live load deflection of the composite section. If shoring is used, then the total deflection will result from the dead and live loads on the composite section. Account must be taken of the fact that concrete is subject to creep under long-time loadings and that shrinkage will occur. This inelastic behavior may be approximated by multiplying the modular ratio n by a factor to reduce the net effective width. The result is a reduced moment of inertia for the composite section that is used in computing the dead-load deflection. The live-load deflection is then usually computed on the basis of the elastic composite moment of inertia. Because the concrete slab in building construction is normally not too thick, creep deflection is not considered to be a problem. AISC (2) gives no indication that one need be concerned with anything but live-load short-time deflection. The steel section, exhibiting no creep, and representing the principal carrying element, infers that creep problems will usually be minimal.

2.12 APPLICATIONS IN BUILDINGS

From the discussion so far, it is clear that composite construction can have limitless possibilities and many applications. Although principles of composite construction do not vary in terms of application, the construction techniques and the applied loads influence the use of composite construction. In Table (2.2) are just a few examples of composite construction used in tall buildings used as residential (apartment) buildings, office buildings, hotels, schools, multistory garages, and combinations thereof.

Table 2.2 Examples of Buildings with Composite Floor System (8)

Type of Structure	Building	Location
Bundled Tube	Sears Towers	Chicago, IL
Tube in Tube	CBS Building	New York, NY
Composite (concrete tube steel interior)	One Shell Square	New Orleans, LA
Framed Tube	Xerox Building	Rochester, NY
Exterior Frame and Care	LaSalle Plaza	Chicago, IL

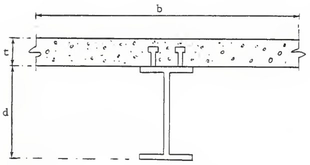
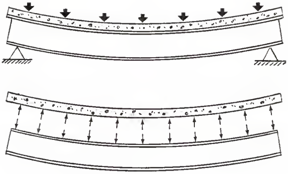
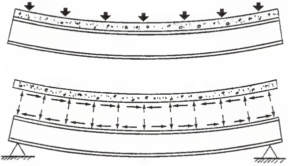


Fig. 2.1 Composite Cross Section

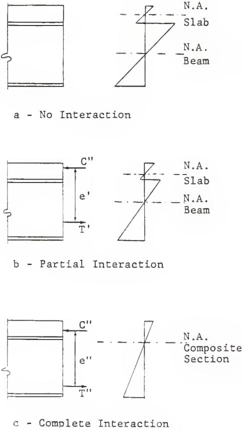


a - Noncomposite Beam



b - Composite Beam

Fig. 2.2 Noncomposite Beam vs. Composite Beam



a - No Interaction

b - Partial Interaction

c - Complete Interaction

Fig. 2.3 Strain Distributions

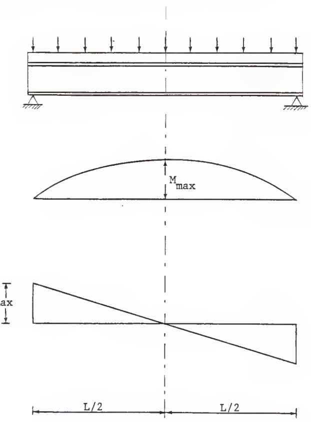


Fig. 2.4 Shear Variation in Simply Supported Beam With Uniformly Distributed Load

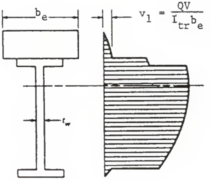
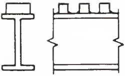
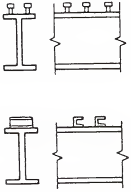


Fig. 2.5 Shear Stress Distribution in Composite Section

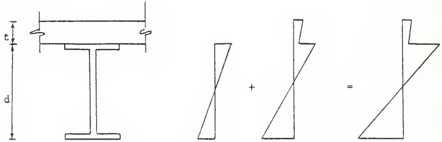


a - Rigid Connector - Bar Type

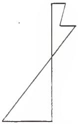


b - Flexible Connectors

Fig. 2.6 Shear Connectors



a - Without Shoring



b - With Shoring

Fig. 2.7 Stress Distribution in Composite Section

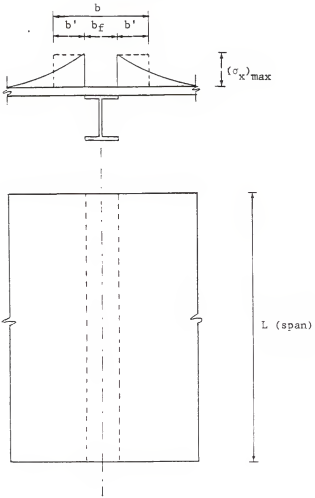


Fig. 2.8 Nonuniform Distribution of Compressive Stress σ_x

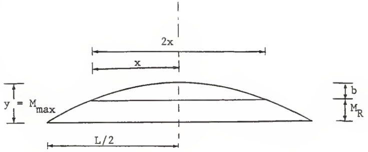


Fig. 2.9 Cover Plate Cutoff Points - Mathematical Method

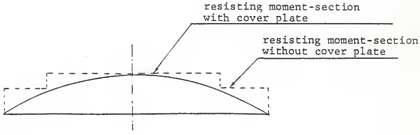


Fig. 2.10 Cover Plate Cutoff Points - Graphical Method

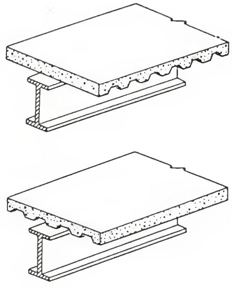


Fig. 2.11 Composite Section With Metal Steel Deck

3. DESIGN CRITERIA

3.1 GENERAL

The AISC Specification (2) provisions for the design of composite beams are based on ultimate load considerations, even though they are presented in terms of working stresses.

For both shored and unshored beams with mechanically anchored slabs, design of the steel beam is based on the assumption that composite action resists the total design moment (Sec. 1.11.2.2 AISC). In shored construction, flexural stress in the concrete slab due to composite action is determined from the total moment. In unshored construction, flexural stress in the concrete slab due to composite action is determined from moment M_L, produced by load imposed after the concrete has achieved 75% of its required strength.

3.2 STRESSES

According to the AISC Specification (2) the stress at the top fiber of the concrete slab must not exceed 0.45 of the ultimate strength, f'_c.

Stress in the steel beam must not exceed 0.66 of the yield strength, F_y.

For construction without shoring, stress in the steel beam may be computed from the total dead plus live load moment and the transformed section modulus, S_{tr}, provided that the numerical value of S_{tr} so used shall not exceed:

$$S_{tr} = (1.35 + 0.35 \frac{M_L}{M_D}) S_s \tag{3.1}$$

where M_L is the moment due to all loads (dead plus live) which will apply after the concrete attains 75% of the required strength, M_D is the moment due to dead load, and S_s is the section modulus for the steel beam.

Shear stress in the web of the steel beam should not exceed 0.4 of the yield strength, F_y.

3.3 LATERAL SUPPORT

For unshored construction, continuous lateral support is assumed if the distance between point of lateral support is the smaller of

$$L \leqq \frac{76.0\ b_f}{\sqrt{F_y}} \tag{3.2.a}$$

or

$$L \leqq 20{,}000/(d/A_f)\ F_y \tag{3.2.b}$$

If these conditions are satisfied, $F_b = 0.66\ F_y$.

If $\quad \sqrt{\frac{102 \times 10^3\ C_b}{F_y}} \leqq \frac{L}{r_T} \leqq \sqrt{\frac{510 \times 10^3\ C_b}{F_y}}$

then $\quad F_b = \left(\frac{2}{3} - \frac{F_y\ (L/r_T)^2}{1530 \times 10^3\ C_b}\right) F_y \qquad (3.3)$

If $\quad \frac{L}{r_T} \geqq \sqrt{\frac{510 \times 10^3\ C_b}{F_y}}$

then $\quad F_b = \frac{170 \times 10^3\ C_b}{(L/r_T)^2} \qquad (3.4)$

or when the compression flange is solid and approximately rectangular

$$F_b = \frac{12 \times 10^3 \; C_b}{L_d/A_f} \tag{3.5}$$

3.4 DEFLECTION

The AISC Commentary (2) suggest a limiting depth/span ratio to prevent excessive deflection as follows:

L/22 for F_y = 36 ksi

L/18 for F_y = 50 ksi

According to AISC(2), the maximum live load deflection for beams and girders supporting plastered ceilings should not exceed 1/360 of the span.

3.5 SHEAR CONNECTORS

Except in the case of encased beams, the entire horizontal shear at the junction of the steel beam and the concrete slab shall be assumed to be transferred by shear connectors welded to the top flange of the beam and embedded in the concrete. The total horizontal shear to be resisted between the point of maximum positive moment and point of zero moment shall be taken as the smaller of

$$V_h = 0.85 \; f'_c \; A_c/2 \tag{3.6.a}$$

and

$$V_h = A_s F_y/2 \tag{3.6.b}$$

where

f'_c = specified compressive strength of concrete, kips.

A_c = actual area of effective concrete flange

A_s = area of steel beam, square inches

The number of connectors resisting the horizontal shear V_h, each side of the point of maximum moment, shall not be less than that determined by the relationship V_h/q, where q, the allowable shear load for one connector, is given in Table 3.1 for flat soffit concrete slabs.

In case of concentrated loads the connectors required each side of the point of maximum moment in an area of positive bending may be uniformly distributed between that point and adjacent points of zero moment, except that N_2, the number of shear connectors required between any concentrated load in that area and the nearest point of zero moment, shall be not less than that determined by equation (3.7).

$$N_2 = \frac{N_1 [MB/M_{max} - 1]}{B-1} \qquad (3.7)$$

where

M = moment (less than the maximum moment at a concentrated load point

N_1 = number of connectors required between point of maximum moment and point of zero moment, determined by the relationship V_h/q.

$$B = \frac{S_{tr}}{S_s}$$

Shear connectors shall have at least 1 inch of lateral concrete cover, except for connectors installed in the ribs of formed steel deck. Unless located directly over the web, the diameter of studs shall not be greater than 2.5 times the thickness of the flange to which they are welded. The minimum center-to-center spacing of stud connectors shall be 6 diameters along the longitudinal axis of the supporting composite beam and 4 diameters transverse to the longitudinal axis of the supporting composite beam. The maximum center-to-center spacing of stud connectors shall not exceed 8 times the total slab thickness.

Table 3.1

Allowable Horizontal Shear Load for One Connector (q) kips

CONNECTOR	Specified compressive strength of concrete (f'_c), ksi		
	3.0	3.5	≧4.0
1/2" diam. * 2" hooked or headed stud	5.1	5.5	5.4
5/8" diam. * 2 1/2" hooked or headed stud	8.0	8.6	9.2
3/4" diam. * 3" hooked or headed stud	11.5	12.5	13.3
7/8" diam. * 3 1/2" hooked headed stud	15.6	16.8	18.0

3.6 COMPOSITE BEAMS WITH FORMED STEEL DECK

Composite construction of concrete slabs on formed steel deck connected to steel beams or girders shall be designed by the applicable portions of sections 1.11.1 through 1.11.4 (AISC) (2).

3.6.1 GENERAL

A. Nominal rib height of the metal deck should not exceed 3 inches.

B. The average width of concrete rib or haunch, W_r, shall be not less than 2 inches, but shall not be taken in calculation as more than the minimum clear width near the top of the steel deck, Fig. 3.1.

C. The concrete slab shall be connected to the steel beam with welded stud shear connectors 3/4 inches or less in diameter. Studs may be welded through the deck or directly to the steel member.

D. Stud shear connectors shall extend not less than 1 1/2 inches above the top of the steel deck after installation.

E. Total slab thickness, including ribs, shall be used in determining the effective width of concrete flange.

F. The slab thickness above the steel deck shall be not less than 2 inches.

3.6.2 DECK WITH RIBS ORIENTED PERPENDICULAR TO THE BEAM

A. Concrete below the top of the steel deck shall be neglected when determining section properties and in calculating A_c for Equation (3.6.a).

B. The spacing of stud shear connectors along the length of a supporting beam shall not exceed 32 inches.

C. The allowable horizontal shear load per stud connector, q, shall be the value stipulated in Table 3.1, multiplied by the following reduction factor:

$$\left(\frac{.85}{N_r}\right)\left(\frac{W_r}{h_r}\right)\left(\frac{H_s}{h_r} - 1.0\right) \leq 1.0 \qquad (3.8)$$

where

h_r = nominal rib height, inches

H_s = length of stud connector after welding, inches not to exceed the value (h_r + 3) in computation, although the actual length may be greater.

N_r = number of stud connectors in one rib, not to exceed 3 in. computations, although more than 3 studs mav be installed.

W_r = average width of concrete rib, inches.

E. To resist unlift, the steel deck shall be anchored to all compositely designed beams at a spacing not to exceed 16 inches. Such anchorage may be provided by stud connectors, a combination of stud connectors and arc spot (puddle) weld, or other devices specified by the designer.

3.6.3 DECK WITH RIBS ORIENTED PARALLEL TO THE BEAM

A. Concrete below the top of the steel deck may be included when determining section properties and shall be included in calculating A_c for Equation (3.6.a).

B. Steel deck ribs over supporting beams may be split longitudinally and separated to form a concrete haunch.

C. When the nominal depth of steel deck is 1 1/2 inches or greater, the average width, W_r, of the supported haunch or rib shall be not less than 2 inches for the first stud in the transverse row plus 4 stud diameters for each additional stud.

D. The allowable horizontal shear load per stud connector, q, shall be the value stipulated in Table 3.1, except that when the ratio W_r/h_r is less than 1.5, the allowable load shall be multiplied by the following reduction factor:

$$0.6 \left(\frac{W_r}{h_r}\right)\left(\frac{H_s}{h_r} - 1.0\right) \leq 1.0 \qquad (3.9)$$

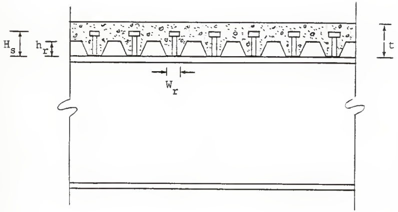


Fig. 3.1 Metal Deck Cross Section

4. MAIN PARAMETERS

There are several parameters upon which composite beam design and the computer program are based.

1. SPAN LENGTH

   The span length is the longitudinal distance in feet between the centerlines of the two simply supported ends.

2. BEAM SPACING

   Beam spacing is the distance in feet, center-to-center, between the steel beams.

3. YIELD STRENGTH OF THE STEEL

   The yield strength of the steel is the specified minimum stress of the steel used for the beams. This program allows for yield strengths of 36 and 50 ksi. only.

4. ULTIMATE STRENGTH OF THE CONCRETE

   The ultimate strength of the concrete is the strength at which the concrete reaches a strain of .003. This program allows for ultimate strengths of 3000 to 8000 psi.

5. LOADS

   Composite beams usually carry uniformly distributed loads which consist of the weight of the beam plus the weight of the concrete slab and the live loads which are located in the distance between the center lines of the beams (S). In some cases there are concentrated loads introduced by transverse beams. This program permits the design of beams carrying uniformly distributed loads and/or any number of concentrated loads.

6. SLAB

The slab used in the composite section depends on the formwork used in construction. If traditional formwork is used, the slab will be a plate soffit, solid slab. If a formed metal deck is used, the slab will be a ribbed slab with a soffit the same as the metal deck itself. Usually the ribs are oriented perpendicular to the beam. This program permits the design of composite beams with any of the three cases mentioned above.

7. STEEL BEAM

The steel beam carries the entire tensile force, and may carry part of the compression force if the neutral axis is located below the slab. Beams are usually simply supported, and positioned parallel to each other, spaced a distance (S) center-to-center. For normal design the beam is a standard rolled steel section, but in some cases where the span is long with heavy loads, the beam may be a built-up section. In cases where there is a limitation on the depth the use of coverplates may be required. This program permits the design of the most economical section by picking a suitable beam from the AISC Table (2) which is stored in the program. Calculations are performed to check the safety of that section. If that section is not available, the program can review any other standard section available. The program also can review a built-up section if a built-up section is desired. Finally, for a depth restriction, the program can pick a suitable beam from the AISC (2) special table of wide beams collected specially for depth restriction design which is also stored in the program. Then the calculations for checking the safety of that section are performed. If that section is unsafe, the program will use coverplates with a starting thickness of 0.25 inch, then repeat the calculations for checking the new section. Again, if the section is unsafe, the program will increase the coverplate thickness by a 0.125 increment and proceed with the calculation automatically until the section satisfies all AISC requirements. If the thickness of the coverplate reaches 1.5 inches and the section is still unsafe, the program will stop and print that the permitted depth is too small.

8. SHEAR CONNECTORS

Shear connectors are the devices which insure that composite action between the concrete slab and the supporting beam is achieved. This program permits the calculation of the number and location of headed stud connectors required for the given loads. A table of the studs' capacities will be shown on the screen to help the user choose the desired capacity of each stud according to stud diameter and concrete strength.

5. ANALYSIS AND DESIGN PROCEDURES

The design of a composite section is executed according to the AISC (2) procedure as follows:

1. Allowable stresses:

   Allowable stress of top fiber of the concrete slab is $F_c = 0.45\ f'_c$ (5.1)

   Allowable stress for steel beam is

   $F_b = 0.66\ Fy$. (5.2)

   Allowable shear stress in the web of the steel beam is

   $$F_v = 0.4\ F_y \quad (5.3)$$

   allowable live load deflection $\Delta_{LL} = \frac{L}{360}$ (5.4)

2. Loads

   A - dead load

   = weight of the concrete slab which is located within a distance (s) plus the weight of the steel beam

   $= t * W_c * S + W_s$ (kips/ft) (5.5)

   where

   t is the slab thickness

   W_c is the unit weight of the concrete

   W_s is the weight of the steel beam, which can be assumed to be .007 kips/ft2 for preliminary design

   S is the beam spacing

B - Live Load

Live load consists of all the loads added after the concrete has attained 75% of its strength

$$= W_L \text{ (kips/ft)} \tag{5.6}$$

3. Moment

A - Beam carrying uniformly distributed load only

$$M_D = \frac{W_L * L^2}{8} \tag{5.7}$$

$$M_L = \frac{W_L * L^2}{8} \tag{5.8}$$

$$M_T = M_D + M_L \tag{5.9}$$

B - Beam carrying uniformly distributed loads and/or concentrated loads.

The bending moment is calulated as follows:

Moment due to dead load

reaction

$$R_1 = \frac{W_D * L}{2} + \Sigma \frac{P_D \times C(I)}{L} \tag{5.10}$$

point of zero shear (x)

$$X = \frac{R_1 - \Sigma P_D(I)}{W_D} \tag{5.11}$$

Maximum moment

$$M_D = R_1 * X - W_D * X^2/2$$

$$- \Sigma P_D(I) * C(I) \tag{5.12}$$

Moment due to live load

reaction

$$R_2 = \frac{W_L * L}{2} + \Sigma \frac{P_L(I) * C(I)}{L} \qquad (5.13)$$

point of zero shear

$$X = \frac{R_2 - \Sigma P_L(I)}{W_L} \qquad (5.14)$$

maximum moment

$$M_L = [R_2 * X - W_L * X^2/2] - \Sigma P_L(I) * C(I) \qquad (5.15)$$

$$M_T = M_D = M_L \qquad (5.16)$$

4. Selection of the Beam

A - The required composite section modulus S_{tr} with reference to the tension fiber is

$$S_{tr\ (required)} = \frac{M_T}{F_b} \qquad (5.17)$$

where

F_b is the allowable service-load stress = .66 F_y

B - The required steel beam section modulus before the concrete has hardened is

$$S_{s\ (required)} = \frac{M_D}{F_b} \qquad (5.18)$$

Using the two known values S_{tr} and S_s a beam can be selected for preliminary design from the AISC table.

5. Actual Loads and Moments

Once the beam has been selected a re-calculation of the dead load is executed using the same procedures as Section 5.3.

6. Calculate effective width of the slab. The effective width of the slab is the smallest of the following.

For interior beams

$$b = L/4 \tag{5.19.a}$$

$$b = s \tag{5.19.b}$$

$$b = b_f + 16t \tag{5.19.c}$$

For exterior beams

$$b = L/12 + b_f \tag{5.20.a}$$

$$b = L/2 + (S + b_f) \tag{5.20.b}$$

$$b = b_f + 6t \tag{5.20.c}$$

7. Calculate modular ratio (n)

$$n = \frac{E}{E_c} \tag{5.21}$$

8. Calculate the transformed section properties

$$A_c = \frac{b * t}{n} \tag{5.22}$$

$$Y = \frac{A_c * t}{2} + A_s\ (d/2 + t) \tag{5.23}$$

transformed moment of inertia

$$I_{tr} = \frac{b * t^3}{12n} + A_c\ (Y - t/2)^2 + I_s + A_s\ (d/2 + t - Y)^2 \tag{5.24}$$

where d is steel beam depth

t is the slab thickness

Note

When a coverplate is used the effect of that coverplate on the area and moment of inertia should be taken into consideration.

9. Check of Stresses

Stress at the top fiber of the concrete

$$f_c = M_L * Y/n\, I_{tr} \tag{5.25}$$

Stress at the bottom fiber of the steel beam

$$f_s = M_T * (d + t - Y)/I_{tr} \tag{5.26}$$

Stress at the top fiber of the steel beam before the concrete hardens.

$$f_b = M_D/S_s \tag{5.27}$$

10. Check AISC for Formula

$$S_{tr}\ (\text{effective}) \leqq (1.35 + 0.35\ \frac{M_L}{M_D})\ S_s \tag{5.28}$$

If the section fails to comply with this condition, the program will pick the next bigger section until this condition is satisfied.

11. Deflection

Beams carrying uniformly distributed load only.

$$\Delta_{LL} = \frac{M_L * L^2}{160\ I_{tr}} \tag{5.29}$$

Beams carrying uniformly distributed load and/or concentrated loads.

The deflection will be calculated using the conjugate beam method.

12. Check if lateral support is required during construction

The AISC (2) Equations 3.2, 3.3 and 3.4 are used to determine the maximum bending stress in the compression flange of a rolled steel section or built-up section with equal flanges according to the laterally unsupported length of the compression flange areas. For a composite design the bending stress due to construction loads. are already known. Solving these equations for L, the unsupported length.

$$\ell = r_T \sqrt{\frac{170 \times 10^3}{f_b}}$$

$$L_d = r_T \sqrt{\frac{5/10 \times 10^3}{F_y}} \qquad (3.4)$$

If $\ell > L_d$, then $\ell_b = \ell$

$$\text{If } \ell < L_d\text{, then } \ell_b = r_T \sqrt{\frac{1530 \times 10^3}{F_y} \left(\frac{2}{3} - \frac{f_b}{F_y}\right)} \qquad (3.3)$$

For beams with equal flange areas the AISC Specification (2) also provides another formula (Formula 1.5-7) from which the maximum unbraced length could be calculated. This formula has not been used in the current program; therefore the maximum unbraced length calculated in the program will be conservative in some cases.

where

f_b = the stress due to dead load moment

F_y = steel yield stress

r_T = radius of gyration of a section comprising the compression flange plus 1/3 of the compression web area, taken about an axis in the plane of the plane of the web.

d = steel section depth

A_f = area of the compression flange

ℓ_b = the maximum permissible laterally unsupported length.

Note

C_b is taken = 1 in the above equations because there is no moment at the ends of a simply supported beam.

13. Shear Connectors

The number and location of the shear connectors vary according to the loading (uniformly distributed or concentrated loads). They also vary according to the condition of the slab. For more details see Sections 3.5 and 3.6.

6. FLOW DIAGRAM

6.1 SIMPLIFIED FLOW DIAGRAM

The simplified flow diagram, shown in Fig. 6.1, is designed to illustrate the main variables in the program and also the output. In the beginning the user should input the material properties, span, and loading. Then he should choose one of the following types of slabs: solid slab; slab on formed steel deck with ribs running perpendicular to the beam; or slab on formed steel deck with ribs running parallel to the beam. In the case of a solid slab, the user has the option of inputting the slab thickness or having it computed by the program. The user also should input if the beam is an interior or exterior beam. Then he should choose one of the following cases for the steel beam: design most economical section; review a specific standard section; review a built-up section; or design for a depth restruction. The output includes the following: the input data; the allowable stresses; slab type and thickness; steel beam section and condition of design; maximum moment and shear; composite section properties; actual stresses; maximum lateral buckling length during construction; the difference between the allowable and actual stresses, i.e., the safety and economy of the section; length, width, thickness and cut-off points of the coverplate, if any; and, finally, the number and location of the shear studs.

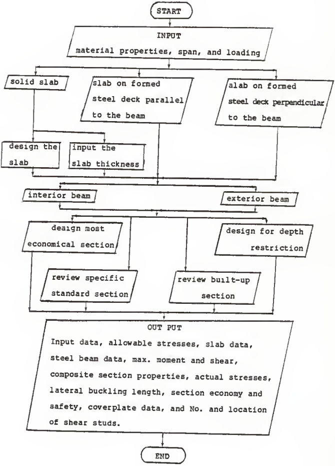


Fig. 6.1 Simplified Flow Diagram

6.2 DETAILED FLOW DIAGRAM

The detailed flow diagram shown in Fig. 6.2 illustrates the logic sequence which has been used in the program to achieve the design of composite beam sections.

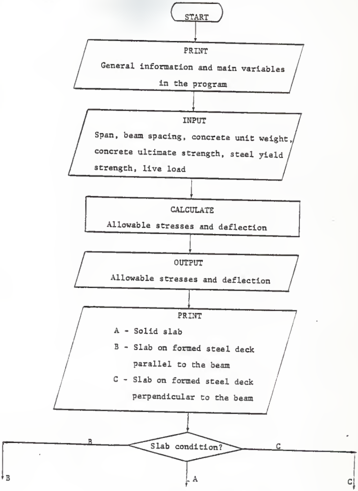


Fig. 6.2 Detailed Flow Diagram

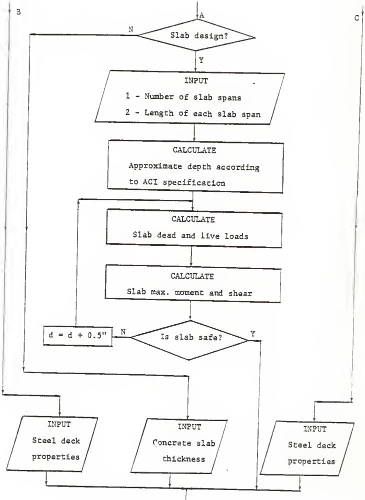


Fig. 6.2 Detailed Flow Diagram (cont.)

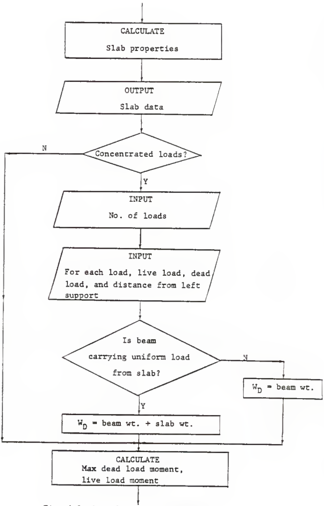


Fig. 6.2 . Detailed Flow Diagram (cont.)

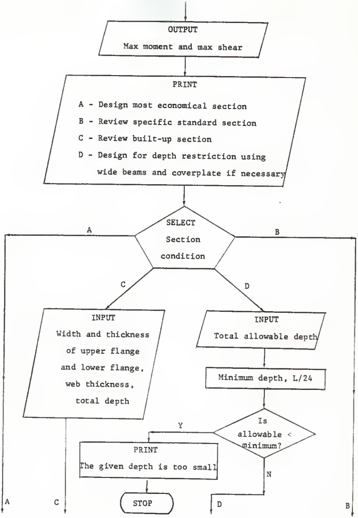


Fig. 6.2 Detailed Flow Diagram (cont.)

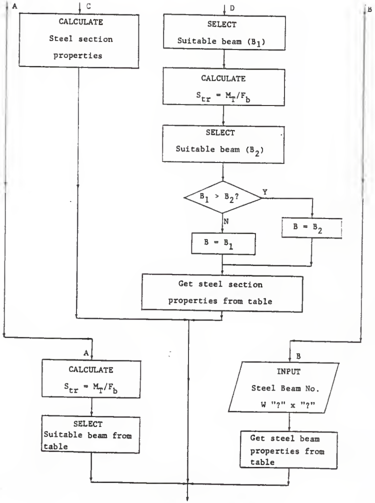


Fig. 6.2 Detailed Flow Diagram (cont.)

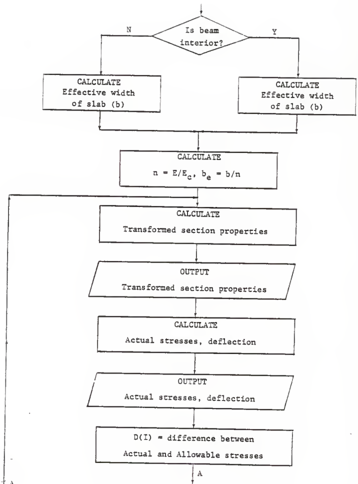


Fig. 6.2 Detailed Flow Diagram (cont.)

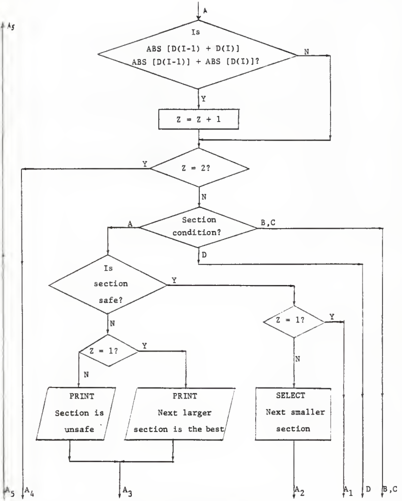


Fig. 6.2 Detailed Flow Diagram (cont.)

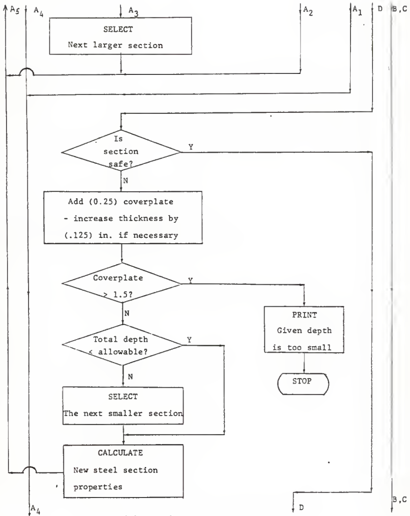


Fig. 6.2 Detailed Flow Diagram (cont.)

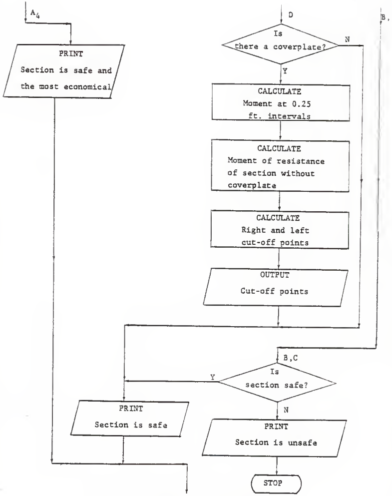


Fig. 6.2 Detailed Flow Diagram (cont.)

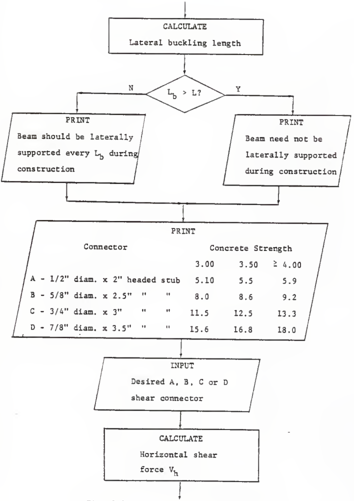


Fig. 6.2 Detailed Flow Diagram (cont.)

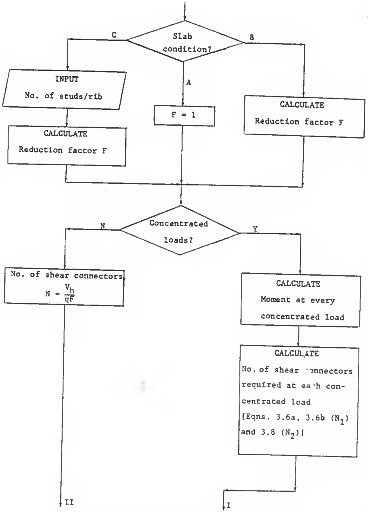


Fig. 6.2 Detailed Flow Diagram (cont.)

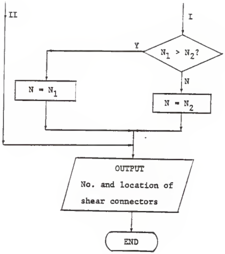


Fig. 6.2 Detailed Flow Diagram (cont.)

7. DESIGN EXAMPLES

7.1 Example 1

Problem Statement

Design a composite interior floor beam of an office building. There is no depth restriction. Do not use temporary shores. Limit dead load deflection to 1 1/2 inches and live load deflection to L/360 given:

span length $L = 36$ ft.

beam spacing $s = 8$ ft.

slab thickness $t = 4$ inches

concrete:

ultimate strength $f'_c = 3000$ psi

unit weight = 145 pcf

steel yield strength $F_y = 36$ ksi

live load $W_L = 100$ lbs./ft.^{2}

partition load = 100 lbs./ft.^{2}

ceiling load = 8 lbs./ft.^{2}

7.2 Example 2

Problem Statement

Design the composite beam in Example 1 using 2 inch formed steel deck with ribs running perpendicular to the beam.

7.3 Example 3

Problem Statement

Design the beam in Example 1 using 2 inch formed steel deck with ribs running parallel to the beam.

Solution

The results of the solutions of these three examples using the computer program are shown on pages 122 to 127. The details of the calculations are presented in the AISC Manual of Steel Construction (2), pages 2.98 - 2.106. For the first example the results from the computer program are the same as in the Manual. For the other two examples the program selected the next lighter sections compared to the beams selected by the manual due to the revision of the dead weight of the beam during the solution.

7.4 Example 4

Problem Statement

Design beam B for the situation shown below (Fig. 7.1). Because of clearance limitations, beam B cannot exceed 30 inches in depth below the slab (use coverplate if necessary). Given:

slab thickness = 4.5 in.
concrete ultimate strength = 3000 psi
steel yield strength = 30 ksi

Solution

The results of the solution using the computer program are shown on pages 128 to 130. The details of the calculation are as follows.

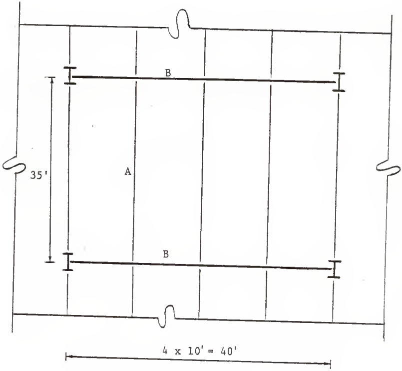
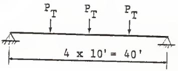


Fig. 7.1 Floor System for Example 4

$P_D = 21.8$ K

$P_L = 45.5$ K

$P_T = 21.8 + 45.5 = 67.3$ K



Solution:

(1) Loads

Weight of the steel beam and concentrated loads only.

Assume weight of the beam = .007 kips/ft^2

$W_D = .007 \times 35 = 0.245$ kips/ft

(2) Moment

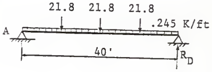
Moment due to dead loads

$\Sigma M_A = 0$

$21.8\ [10 + 20 + 30]$

$+ \dfrac{.245 \times (40)^2}{2} = 40\ R_2$

$R_D = 37.6$ kips



Max moment, occurs at the point of zero shear, at mid span.

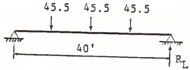
$M_{D\ max} = 37.6 \times 20 - 21.8 \times 10$

$- \dfrac{.245 \times (20)^2}{2}$

$= 485$ kips-ft

Moment due to live load

$R_L = 45.5 \times 1.5 = 68.25$ K



Max moment at mid span.

$$M_{L\ max} = 68.25 \times 20 - 45.5 \times 10$$
$$= 910 \text{ kips-ft}$$

Because of symmetry of the dead and live load, the point of zero shear is still at mid span, and the total moment equals to $M_D + M_L$ without further calculation.

$$M_T = M_D = M_L$$
$$= 485 + 910 = 1395 \text{ kips-ft}$$

(3) Selection of the Beam

$$S_{tr} \text{ (required)} = \frac{M_T}{24} = \frac{1395 \times 12}{24}$$
$$= 697.5 \text{ in.}^3$$

$$S \quad \text{(required)} = \frac{M_D}{24} = \frac{485 \times 12}{24}$$
$$= 242.5 \text{ in.}^3$$

from AISC Table (2) try W36 x 170

with depth = 36.17 in. > 30 in.

<u>No good</u>

So we will try to choose the beam which matches the allowable depth, then add a coverplate if necessary.

Try 27 x 102

$A = 30 \text{ in.}^2$	$d = 27.09''$
$b_f = 10.015''$	$t_f = .83''$
$t_w = .515''$	$I_s = 3620 \text{ in.}^4$

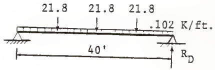
(4) Recalculation

steel beam weight = 0.102 kips/ft

$R_D = [21.8\ (10 + 20 + 30)$

$+ \frac{.102 \times (40)^2}{2}]/40$

$= 34.74$ kips



$M_D = 34.74 \times 20 - 21.8 \times 10 - \frac{.102 \times (20)^2}{2}$

$= 456.4$ kips-ft

$M_T = M_D + M_L = 456.4 + 910$

$= 1366$ kips-ft

Max shear force

$V = R_D + R_L$

$= 34.74 + 68.25 = 102.99 = 103$ kips

(5) **Effective Slab Width**

$b = \frac{L}{4} = \frac{40 \times 12}{4} = 120$ in. or

$b = 16t + b_f$

$= 16 \times 4.5 + 10.015 = 82.01$ in. (governs) or

$b = s = 35 \times 12 = 420$ in.

(6) Section modulus

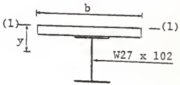
$f'_c = 3000$ psi, i.e., $n = 9$

$b_e = \frac{b}{9} = \frac{82.01}{9} = 9.113$ in.

(7) **Transformed Section Properties**

$A_T = 4.5 \times 9.113 + 30 =$

$= 71.01$ in.^{2}



$$\Sigma M_{1-1} = 9.113 \times \frac{(4.5)^2}{2} + 30 \times (\frac{27.09}{2} + 4.5) = 71.01y$$

$$y = 8.92''$$

$$I_{tr} = \frac{9.113 \times (4.5)^3}{12} + 9.113 \times 4.5 \times (\frac{4.5}{2} - 8.92)^2$$

$$+ 3620 + 30 \times (\frac{27.09}{2} + 4.5 - 8.92)^2$$

$$= 8011 \quad \text{in.}^4$$

(8) Check of Stresses

$$f_c = \frac{M_L * y}{n\ I_{tr}} = \frac{910 \times 12 \times 8.92}{9 \times 8011} = 1.351 \text{ ksi} \quad (> F_c \text{ allowable})$$

stress in the concrete is unsafe.

$$f_b \text{ (bottom)} = \frac{M_T * y}{I_{tr}} = \frac{1366 \times 12(27.09 + 4.5 - 8.92)}{8011}$$

$$= 46.39 \text{ ksi} \quad (> F_b \text{ allowable})$$

$$f_b \text{ (top)} = \frac{M_D * y}{I} = \frac{456.4 \times 12 \times 27.09/2}{3620} = 20.49 \text{ ksi}$$

This section is unsafe. Try a coverplate with a thickness of 1.5 in. and a width of 9 in.. The program will use a coverplate with a starting thickness of 0.25 in., then check the stresses. An increment of 0.125 in. will be added if necessary until the section is adequate.

RECALCULATION OF THE DEAD LOAD

$$W_D = .102 + 30.6 \times 1.5/1000$$

$$= .148 \text{ kips/ft}^2$$

$$R_D = 1.5 \times 21.8 + 20 \times .148$$

$$= 35.66 \text{ kips}$$

$$M_D = 35.66 \times 20 - 21.8 \times 10 - \frac{(20)^2 \times .148}{2}$$

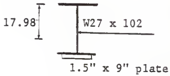
$$= 465.6 \text{ kips-ft}$$

$$M_T = 465.6 + 910 = 1375.6 \text{ kips-ft}$$

$$R_T = V = 35.66 + 68.25 = 103.9 \text{ kips}$$

PROPERTIES OF THE STEEL SECTION

$$A_s = 30 + 1.5 \times 9 = 43.5 \text{ in.}^2$$



$$Y_s = [30 \times \frac{27.09}{2} + 13.5\ (\frac{1.5}{2} + 27.09)]/43.5$$

$$= 17.98 \text{ in.}$$

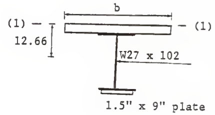
$$I_s = 3620 + 30 \times (\frac{27.09}{2} - 17.98)^2$$

$$+ \frac{9 \times (1.5)^3}{12} + 13.5 \times (.75 + 27.09 - 17.98)^2$$

$$= 5525.07 \text{ in.}^4$$

$$S_s = \frac{5525.07}{(27.09 + 1.5 - 17.98)} = 520.74 \text{ in.}^3$$

PROPERTIES OF THE TRANSFORMED SECTION



$$A_T = 9.113 \times 4.5 + 30 + 1.5 \times 9 = 84.51 \text{ in.}^2$$

$$\Sigma M_{1-1} = 9.113 \times \frac{(4.5)^2}{2} + 30\left(\frac{27.09}{2} + 4.5\right) + 1.5 \times 9 \times \left(27.09 + 4.5 + \frac{1.5}{2}\right)$$

$$= 84.51\ y$$

$$y = 12.66 \text{ in.}$$

$$I_{tr} = \frac{9.113 \times (4.5)^3}{12} + 9.113 \times 4.5 \times \left(\frac{4.5}{2} - 12.66\right)^2 + 3620 + 30\left(\frac{27.09}{2} + 4.5 - 12.66\right)^2 + \frac{9 \times (1.5)^3}{12} + 9 \times 1.5 \times \left(\frac{1.5}{2} + 27.09 + 4.5 - 12.66\right)^2$$

$$= 14234 \text{ in.}^4$$

CHECK OF STRESSES

$$f_c = \frac{M_L * y}{n\ I_{tr}} = \frac{910 \times 12 \times 12.66}{9 \times 14234}$$

$$= 1.079 \text{ ksi} \qquad (< F_c \text{ allowable})$$

$$f_b \text{ (bottom)} = \frac{M_T * y}{I_{tr}}$$

$$= \frac{1375.60 \times 12 \times (27.09 + 1.5 + 4.5 - 12.66)}{14234}$$

$$= 23.69 \text{ ksi} \qquad (< F_b \text{ allowable})$$

$$f_b \text{ (top)} = \frac{M_D * y}{I}$$

$$= \frac{465.60 \times 17.98 \times 12}{5525} = 18.18 \text{ ksi}$$

shear stress in the web

$$f_v = \frac{V}{A_{web}} = \frac{103.9}{27.09 \times .515} = 7.45 \text{ ksi} \quad (< F_v \text{ allowable}) \quad \text{o.k.}$$

REMARKS

The difference between the allowable and actual stresses is:

$$\left(\frac{24 - 23.69}{24}\right) \times 100 = 1.3\%$$

Since the difference between the stresses is small, this section is safe and economical.

LENGTH OF COVER PLATE

The moment at which the coverplate is not needed (theoretically) is:

$$M_p = \frac{I_{tr} \; F_b}{y}$$

where I_{tr} is the moment of inertia of the transformed section without the coverplate, F_b is the allowable steel stress and Y is the distance of the fiber of maximum tension for the beam without coverplate.

$$M_P = \frac{8011.59 \times 24}{(27.09 + 4.5 - 8.92) \times 12} = 706.8 \text{ kips-ft.}$$

Assume that the cutoff points lie between the supports and the first loads.

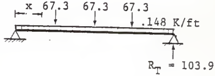
$$M_P = R_T \; x - W_D * \frac{x^2}{2}$$

$$706.8 = 103.9x - 0.074x^2$$

$$x^2 - 1404.05x$$

$$+ 9551.35 = 0$$

$$x = 6.84 \text{ ft.} \simeq 6.5 \text{ ft.}$$



Due to symmetry of loading both right and left cut-off points will be the same distance from the right and left supports. Total theoretical length of the coverplate:

$$= 40 - 2 \times 6.5 = 27 \text{ ft.}$$

Note that the development length should be added to both ends of the coverplate.

(9) Check AISC Formula

$$S_{tr(effective)} \leq [1.35 + 0.35\,(\frac{M_L}{M_D})]\; S_s$$

$$\leq [1.35 + 0.35\,(\frac{910}{465.60})]\; 520.74$$

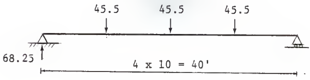
$$\leq 1059.3$$

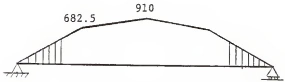
$$S_{tr(effective)} = \frac{I_{tr}}{y} = \frac{14234}{(27.09 + 4.5 + 1.5 - 12.66)}$$

$$= 696.73 < 1059.3 \quad \text{o.k.}$$

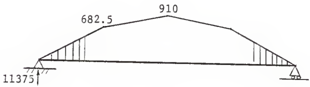
10. Deflection

Deflection will be calculated using the conjugate beam method as follows





Bending moment diagram



conjugate beam loaded with
the bending moment diagram

elastic reaction (RE) at left support

$$RE = 682.5 \times 10 \times .5 + 682.5 \times 10 + (910 - 682.5) \times 10 \times .5$$

$$= 11375 \text{ kip-ft.}$$

Maximum deflection occurs at point of maximum moment, midspan.

$$\Delta_{LL} = \frac{1}{EI} [11375 \times 20 - 682.5 \times 10 \times .5 \times 13.33 - 682.5 \times 10 \times 5 - (910 - 682.5) \times 10 \times .5 \times 3.33]$$

$$= \frac{1}{EI} [144098.51]$$

$$= \frac{144098.5 \times 12^3}{29000 \times 14234.27} = 0.60 \text{ in.}$$

(11) Lateral support

$$A_s \text{ (compression zone)} = 10.015 \times .83 + .515\ (17.98 - .83)/3 = 11.25\ \text{in}^2$$

$$r_T = \sqrt{\frac{.5 \times 139}{11.25}} = 2.48$$

$$\ell = r_T \sqrt{\frac{170 \times 10^3}{f_b}}$$

$$= \frac{2.48}{12} \sqrt{\frac{170{,}000}{18.18}} = 19.98 \text{ ft.}$$

$$L_d = r_T \sqrt{\frac{510 \times 10^3}{F_y}}$$

$$= \frac{2.48}{12} \sqrt{\frac{510{,}000}{36}} = 24.59 \text{ ft.}$$

$$\ell < L_d$$

$$\ell_b = r_T \sqrt{\frac{15030}{F_y} \times 10^3 \left(\frac{2}{3} - \frac{f_b}{F_y}\right)}$$

$$= \frac{2.48}{12} \sqrt{\frac{1530{,}000}{36} \left(\frac{2}{3} - \frac{18.18}{36}\right)}$$

$$= 17.13 \text{ ft.}$$

Beams should be laterally supported at the one-third points, i.e., every 13'-4", during construction.

(12) Shear connectors

Try 3/4" diameter * 3.0" studs

$q = 11.5$

maximum stud diameter =

$2.5\ t_f = 2.5 \times .83 = 2.07 > 0.75$ O.K.

Total horizontal shear.

$$V_h = \frac{.85\ f'_c \times A_c}{2} \qquad (3.6.a)$$

$$= .85 \times 3 \times 82.015 \times 4.5/2$$

$$= 470.56 \text{ Kips (governs)}$$

or

$$V_h = A_s F_y / 2 \qquad (3.6.b)$$

$$= \frac{30 \times 36}{2} = 540 \text{ Kips}$$

Number of studs from point of zero moment to point of maximum moment

$$N = \frac{470.56}{11.5} = 40.9 = 41 \text{ studs}$$

Number of studs from point of zero shear to the first load $N_1 = \frac{41}{2} = 20.5 = 21$ studs

check

$$N_2 = \frac{N_1\ [MB/M_{max} - 1]}{B - 1}$$

$$B = \frac{S_{tr}}{S_s} = \frac{696.73}{520.7} = 1.34$$

Moment at the first concentrated load:

$$M = 103.9 \times 10 - \frac{0.148 \times (10)^2}{2} = 1031.6 \text{ kips-ft}$$

$$N_2 = \frac{21[1031.6 \times 1.34/1375.6 - 1]}{1.34 - 1} = 0.32 < N_1$$

Studs should be uniformly spaced.

No. of Studs	From point	To point
21	0	10
21	10	20
21	20	30
21	30	40

8. SUMMARY

A microcomputer program has been developed to design unshored composite beams with the following variables: ultimate concrete strength from 3000 to 8000 psi; steel yield strength of 36 or 50 ksi; uniformly distributed or concentrated loads or a combination of the two; and solid slab or slab on formed steel deck. The program may design the most economical section, review a specific standard section, review a built-up section or design for depth restriction using a coverplate if necessary. Headed studs are used with different capacities so full composite action can be attained.

9. SUGGESTIONS FOR FURTHER WORK

This program could be expanded to provide the additional features described below.

1. Design of slab on formed steel deck. This design should be carried out in two steps:
   (a) Check the stresses in, and the deflection of, the steel deck under the effect of the wet concrete weight and any load which will be present during construction.
   (b) Design the concrete slab and the steel deck together as a composite section to resist any loads which will be added after the concrete attains 75% of its design strength. In this case the deck will serve as reinforcement for the slab.
2. Design a continuous beam. In this case the beam should be designed as a normal composite section, the same as in this program, where the bending moment is positive. The situation is different in the area of negative bending moment, where the slab is under tension and the steel beam has to take the compression force. The tension force in the slab can be resisted by adding reinforcement to the slab, or the steel beam alone has to resist the whole negative moment.

10. APPENDICES

10.1 REFERENCES

1 - American Concrete Institute, "Building Code Requirements for Reinforced Concrete" (ACI 318-83), Detroit, Michigan, 1983.

2 - American Institute of Steel Construction, "Manual of Steel Construction", 7th and 8th ed., New York, N.Y., 1970 and 1980.

3 - Amon, Rene, "Steel Design for Engineers and Architects", Van Nostrand Reinhold Co., New York, N.Y., 1982.

4 - C.P. Yam, Lloyd, "Design of Composite Steel - Concrete Structures", Surrey University Press, 1981.

5 - Cook, John P., "Composite Construction Methods", John Wiley and Sons, New York, N.Y., 1977.

6 - Fistructe, R.P. Johnson, "Composite Structures of Steel and Concrete", Crosby Lockwood Staples, London, 1975.

7 - McCormac, Jack C., "Structural Steel Design", Intext Educational Publishers, San Francisco, 1971.

8 - Sabris, Gajanon M., "Handbook of Composite Construction Engineering", Van Nostrand Reinhold Company, New York, N.Y., 1979.

9 - Salmon, Charles G., "Steel Structures Design and Behavior", Intext Educational Publishers, San Francisco, 1971.

10.2 NOTATION

A_c Actual area of effective concrete flange in composite design (square inches)

A_s Area of steel beam in composite design (square inches)

E Modulus of elasticity of concrete (kips per square inch)

E_c Modulus of elasticity of concrete (kips per square inch)

F_b Bending stress permitted in the absence of axial force (kips per square inch)

F_v Allowable shear stress (kips per square inch)

F_y Specified minimum yield stress of the type of steel being used (kips per square inch)

I Moment of inertia (inches^4)

I_{tr} Moment of inertia of transformed composite section (inches^4)

L Span length (ft)

S Beam spacing (ft)

M Moment (kip-ft)

M_D Moment produced by dead load (kip-ft)

M_L Moment produced by loads applied after the concrete gets 75% of its strength (kip-ft)

N_1 Number of shear connectors equal to V_h/q

N_2 Number of shear connectors required where closer spacing is needed adjacent to point of zero moment

P Reaction or concentrated transverse load applied to beam (kips)

S_s Section modulus of steel beam in composite design, referred to the bottom flange (inches^3)

S_{tr} Section modulus of transformed composite cross-section, referred to the top flange (inches^3)

V	Statical shear on beam (kips)
V_h	Total horizontal shear to be resisted by connectors under full composite action (kips)
b	Effective width of concrete slab (inches)
b_f	Flange width of rolled beam (inches)
f_c	Concrete working stress (kips per square inch)
f'_c	Specified compressive strength of concrete (kips per square inch)
f_s	Steel working stress (kips per square inch)
n	Modular ratio; equal to E/E_c
q	Allowable horizontal shear to be resisted by a shear connector (kips)
t_f	Flange thickness (inches)
t	Concrete slab thickness (inches)
B	Ratio S_{tr}/S_s
Δ_{LL}	Deflection due to live load (inches)
Δ_{DL}	Deflection due to dead load (inches)
ℓ_b	Length of the beam unsupported in the lateral direction (ft)

10.3 COMPUTER PROGRAM

```
x50 CLS
100 A3$="                        ************************"
150  A1$="**********************"
200 PRINT "THIS IS A PROGRAM TO OESIGN COMPOSITE SECTIONS FOR UNSHORED, SIMPLE B
EAMS        ACCORDING TO THE AISC SPECIFICATION."
250 PRINT " "
300 PRINT A3$
350 PRINT " "
400 INPUT "BEFOR STARTING, WOULO YOU LIKE AN EXPLANATION OF THE THE MAIN VARIABL
ES IN THIS PROGRAM Y/N";Z$
450 IF Z$="Y" THEN 500 ELSE 3000
500 CLS
550 PRINT A3$
600 PRINT "BEFORE STARTING THE PROGRAM, THE MAIN VARIABLES WILL BE DEFINED."
650 PRINT A3$
700 PRINT "THE COMPOSITE SECTION UNDER CONSIDERATION CONSISTS OF A CONCRETE SLAB
 AND STEEL BEAM. IT VARIES ACCORDING TO THE STRENGTH OF THE CONCRETE AND THE STE
EL. IT ALSO VARIES ACCORDING TO THE LOAO, SLAB ANO BEAM CONDITIONS."
750 PRINT A3$
800 PRINT " "
850 PRINT "(1)-CONCRETE STRENGTH "
900 PRINT "    YOU MAY USE CONCRETE STRENGTHS UP TO 8000 PSI"
950 PRINT A3$
1000 PRINT "(2)-STEEL STRENGTH"
1050 PRINT "    YOU MAY USE:"
1100 PRINT "    A-STEEL YIELO STRENGTH FY=36 KSI"
1150 PRINT "    B-STEEL YIELD STRENGTH FY=50 KSI"
1200 PRINT A3$
1250 PRINT " "
1300  INPUT "HAVE YOU FINISHED READING THIS PART OF THE INFORMATION ? Y/N";Z$
1350  IF Z$="Y" THEN 1400  ELSE 1300
1400  CLS
1450  PRINT "(3)-LOAO CONDITION"
1500  REM
1550  PRINT "    YOU MAY SELECT ONE OF THE FOLLOWING CASES:"
1600  PRINT "   A-THE BEAM CARRIES UNIFORMLY DISTRIBUTED LOAD ONLY"
1650  PRINT "   B-THE BEAM CARRIES CONCENTRATED LOADS ONLY"
1700  PRINT "   C-THE BEAM CARRIES BOTH UNIFORMLY DISTRIBUTED ANO CONCENTRATED L
OAOS"
1750 PRINT A3$
1800 PRINT "(4)-SLAB CONDITION"
1850 PRINT "    SLAB MAY BE:"
1900 PRINT "   A-SOLIO SLAB"
1950 PRINT "     YOU MAY HAVE THE PROGRAM OESIGN A SOLIO SLAB ACCOROING TO ACI S
PECIFICA-        TIONS OR YOU MAY INPUT THE SLAB THICKNESS."
2000 PRINT "   B-SLAB ON METAL  OECK WITH RIBS PARALLEL TO THE BEAM"
2050 PRINT "   C-SLAB ON METAL  DECK WITH RIBS PERPENDICULAR TO THE BEAM"
2100 PRINT A3$
2150 PRINT "(5)-BEAM CONDITION"
2200 PRINT "    YOU MAY ASK THE PROGRAM TO :"
2250 PRINT "   A-DESIGN THE MOST ECONOMICAL SECTION"
2300 PRINT "   B-REVIEW A SPECIFIC STANOARD SECTION"
2350 PRINT "   C-REVIEW A BUILT-UP SECTION  "
2400 PRINT "   D-OESIGN FOR OEPTH RESTRICTION USING WIOE BEAM AND COVER PLATE IF
 NECESSARY"
2450 PRINT A3$
2500 INPUT "HAVE YOU FINISHED READING THIS PART OF THE INFORMATION ? Y/N";Z$
```

```
2550 IF Z$="Y" THEN 2600 ELSE 2500
2600 CLS
2650 PRINT "(6)-SHEAR STUD CONNECTORS"
2700 PRINT " "
2750 PRINT "     CONNECTOR CAPACITIES BASED ON STUD DIAMETER AND CONCRETE STRENGT
H WILL BE        DISPLAYED ON THE SCREEN. YOU MAY TH
EN SELECT THE APPROPRIATE CAPACITY."
2800 PRINT A3$
2850 PRINT " "
3000 RUN "COMPOSIT.SEC"
```

```
3000 DIM A(99,12),BB(99,2),D$(25),E(25,12),C(20),F(4,5),BM(400),MCL(20),MCLL(20)
3050 DIM G(10,10),DFS(20),M(20),SC(20),DL(20)
3100 CLS
3150 PRINT "PLEASE WAIT A MOMENT"
3200 PRINT " "
3250 PRINT "THE PRDGRAM IS PRDCEDING"
3300 FDR I=1 TD 99
3310 FDR KK=1 TO 2
3350 READ BB(I,KK)
3360 NEXT KK
3400 FDR J=1 TO 12
3450 READ A(I,J)
3500 NEXT J,I
3550 FDR I=1 TD 4
3600 FDR J=1 TO 5
3650 READ F(I,J)
3700 NEXT J
3750 NEXT I
3800  FOR I=1 TO 24
3850  READ D$(I)
3900  FDR J=1 TD 12
3950  READ E(I,J)
4000  NEXT J,I
4050 CLS
4100 LPRINT "                    COMPOSITE SECTIDN"
4150 LPRINT A3$
4200 INPUT"INPUT BEAM SPAN  --------------------------------- = ?  FT";L
4250 PRINT " "
4300 INPUT"INPUT BEAM  SPACING ------------------------------ = ?  FT";S
4350 PRINT " "
4400 INPUT"INPUT UNIT WEIGHT DF THE CDNCRETE --------------- = ? LB/FT^3";WC
4450 PRINT " "
4500 INPUT"INPUT THE ULTIMATE STRENGTH DF THE CDNCRETE {FC} = ? PSI    ";FC
4550 PRINT " "
4600 PRINT "INPUT THE SUM DF UNIFORMLY DISTRIBUTED DEAD AND LIVE LDADS THAT WILL
-BE"
4650 INPUT "ADDED AFTER THE CDNCRETE GETS 75% DF ITS STRENGTH ---= ? LB/FT^2";WL
4700 L1=INT(L)
4710 ZZZZ=0
4750 PRINT " "
4800 INPUT "INPUT DD YDU HAVE CDNCENTRATED LDADS Y/N";L$
4850 IF L$="N" THEN 5350
4900 INPUT "INPUT HDW MANY CDNCENTRATED LDADS ";N
4950 FDR I=1 TD N
5000 PRINT "FDR LDAD NO. ";I
5050 PRINT A1$
5100 PRINT "NDTE EACH LDAD WILL BE INPUT IN TWD PDRTIONS: DEAD & LIVE "
5150 INPUT "INPUT DEAD LDAD PDRTIDN -------- = ? KIPS ";PD(I)
5200 INPUT "INPUT LIVE LDAD PDRTICN -------- = ? KIPS ";PL(I)
5250 INPUT "INPUT DISTANCE FRDM THE LEFT END = ? FT ";C(I)
5300 NEXT I
5350 CLS
5400 A2$="_____________________________________________________________________
__"
5410 A4$="*****************************************************************"
5450 CLS
5500 IF C ) 1 THEN 6100
5550 PRINT "A-STEEL YIELD STRENGTH     FY=36 KP"
5600 PRINT " "
```

```
5650 PRINT "B-STEEL YIELD STRENGTH     FY=50 KP"
5700 PRINT A3$
5750 PRINT " "
5800 INPUT "INPUT STEEL TYPE  (A)  OR  (B)  ?";T$
5850 REM THE FOLLOWING STEPS CALCULATE THE ALLOWABLE STRESSES AND DEFLECTION
5900 IF T$="A" THEN FS(1)=24:FV(1)=.4*36:FY=36:GOTO 6050
5950 FS(1)= 33:FY=50
6000 FV(1)=.4*50
6050 FC(1)=.45*FC /1000
6100 DA=L*12/360
6150 CLS
6200 PRINT "         THE INPUT DATA "
6250 PRINT A2$
6300 PRINT "BEAM SPAN ----------------------------------------=";L;"FT"
6350 PRINT "BEAM SPACING---------------------------------------=";S;"FT"
6400 PRINT "UNIT WEIGHT OF THE CONCRETE-------------------------=";WC;"LB/FT^3"
6450 PRINT "CONCRETE ULTIMATE STRENGTH ------------------------=";FC;"PSI"
6500 PRINT "STEEL YIELD STRENGTH ------------------------------=";FY;"KSI "
6550 PRINT "LIVE LOAD ----------------------------------------=";WL;"LB/FT^2"
6600 IF L$="N" THEN 7050
6650 PRINT "CONCENTRETED LOADS"
6700 PRINT A1$
6750 FOR I=1 TO N
6800 PRINT "LOAD NO. ";I
6850 PRINT "DEAD LOAD PORTION -------------------------=";PD(I);"KIPS"
6900 PRINT "LIVE LOAD PORTION -------------------------=";PL(I);"KIPS"
6950 PRINT "AT DISTANCE FROM THE LEFT SUPPORT ---------=";C(I);"FT"
7000 NEXT I
7050 PRINT A4$
7100 PRINT "           ALLOWABLE STRESSES AND DEFLECTION        "
7150 PRINT A2$
7200 PRINT "ALLOWABLE COMPRESSIVE STRESS IN CONCRETE SLAB ---------=";FC(1);"KSI
"
7250 PRINT "ALLOWABLE TENSILE STRESS  IN THE STEEL BEAM------------=";FS(1);"KSI
"
7300 PRINT "ALLOWABLE SHEAR STRESSES IN THE STEEL BEAM----------=";FV(1);"KSI "
7350 PRINT "ALLOWABLE DEFLECTION DUE TO LIVE LOAD ------------ ---=";DA;"IN   "
7400 PRINT A2$
7450 INPUT "INPUT DO YOU WANT A COPY OF THE INPUT DATA AND THE ALLOWABLE STRESSE
S Y/N";Z$
7500 IF Z$="N" THEN 8850
7550 LPRINT "         THE INPUT DATA "
7600 LPRINT A2$
7650 LPRINT "BEAM SPAN ----------------------------------------=";L;"FT"
7700 LPRINT "BEAM SPACING---------------------------------------=";S;"FT"
7750 LPRINT "UNIT WEIGHT OF THE CONCRETE-------------------------=";WC;"LB/FT'3"
7800 LPRINT "CONCRETE ULTIMATE STRENGTH ------------------------=";FC;"PSI   "
7850 LPRINT "STEEL YIELD STRENGTH ------------------------------=";FY;"KSI "
7900 LPRINT "LIVE LOAD ----------------------------------------=";WL;"LB/FT^2"
7950 IF L$="N" THEN 8450
8000 LPRINT "CONCENTRATED LOADS"
8050 LPRINT A1$
8100 LPRINT "NO. OF CONCENTRATED LOADS -----------------=";N
8150 FOR I=1 TO N
8200 LPRINT "LOAD NO. ";I
8250 LPRINT "DEAD LOAD PORTION -------------------------=";PD(I);"KIPS"
8300 LPRINT "LIVE LOAD PORTION -------------------------=";PL(I);"KIPS"
8350 LPRINT "AT DISTANCE FROM THE LEFT SUPPORT ---------=";C(I);" FT"
8400 NEXT I
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8500 LPRINT "           ALLOWABLE STRESSES AND DEFLECTION        "
8550 LPRINT A2$
8600 LPRINT "ALLOWABLE COMPRESSIVE STRESS IN CONCRETE SLAB--------=";FC(1);"KSI "
8650 LPRINT "ALLOWABLE TENSILE STRESS IN THE STEEL BEAM-----------=";FS(1);"KSI "
8700 LPRINT "ALLOWABLE SHEAR STRESSES IN THE STEEL BEAM---------=";FV(1);"KIPS"
8750 LPRINT "ALLOWABLE DEFLECTION DUE TO LIVE LOAD ---------------=";DA;"IN   "
8800 LPRINT A2$
8850 CLS
8900 PRINT "A-SOLID SLAB"
8950 PRINT " "
9000 PRINT "B-SLAB ON FORMED STEEL DECK PARALLEL TO THE BEAM"
9050 PRINT " "
9100 PRINT "C-SLAB ON FORMED STEEL DECK PERPENDICULAR TO THE BEAM"
9150 PRINT A3$
9200 PRINT " "
9250 INPUT "INPUT SLAB CONDITION (A) OR (B)  OR  (C) ";A$
9300 CLS
9350 REM THE FOLLOWING STEPS CALCULATE THE AREA AND MOMENT OF INERTIA FOR ONE FO
OT OF THE CONCRETE SLAB
9400 IF A$="A" THEN 9550
9450 IF A$="B" THEN 10250
9500 IF A$="C" THEN 11800
9550 CLS
9600 LPRINT "SOLID SLAB"
9650 LPRINT A1$
9700 INPUT "DO YOU WANT TO DESIGN THE SLAB Y/N ?",B$
9750 IF B$="Y" THEN GOSUB 42600 ELSE 9850
9800 GOTO 9950
9850 INPUT "INPUT THICKNESS OF THE CONCRETE SLAB  =? IN";TC
9900 LPRINT "SLAB THICKNESS ------- =";TC;"IN"
9950 CLS
10000 AC=TC
10050 IC=TC^3/12
10100 YC=TC/2
10150 TS=TC
10200 GOTO 12700
10250 LPRINT "SLAB ON FORMED STEEL DECK PARALLEL TO THE BEAM"
10300 LPRINT A1$
10350 INPUT "INPUT THICKNESS OF THE CONCRETE SLAB ABOVE THE STEEL DECK =? IN";D1
10400 PRINT " "
10450 INPUT "INPUT DEPTH OF THE RIBS ----------------------------= ? IN";D2
10500 PRINT " "
10550 INPUT "INPUT DISTANCE FROM CENTER TO CENTER OF THE RIBS --= ? IN";B1
10600 PRINT " "
10650 INPUT "INPUT TOP CLEAR WIDTH OF THE RIBS ------------------= ? IN";B2
10700 PRINT " "
10750 INPUT "INPUT BOTTOM CLEAR WIDTH OF THE RIBS----------------= ? IN";B3
10800 TC=D1+D2
10850 IF B2 ( B3 THEN  11300
10900 A1=B1*D1+B3*D2+(B2-B3)*D2*.5
10950 AC=A1/B1
11000 M1=B1*D1^2/2 +B3*D2*(D1+D2/2)+(B2-B3)*D2*(D1+D2/3)*.5
11050 YC=M1/A1
11100 PRINT " "
11150 TS=AC
11200 I1=B1*D1^3/12+B1*D1*(YC-D1/2)^2+B3*D2^3/12+B3*D2*(D1+D2-YC-D2/2)^2+(B2-B3)
*D2^3/36+(B2-B3)*D2*.5*(D1+D2-YC-2*D2/3)^2
11250 GOTO 11650
11300 A1=B1*D1+B2*D2
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11350 AC=AI/B1
11400 MI=(B1*DI^2)/2 +B2*D2*(D1+D2/2)
11450 YC=M1/A1
11500 TS=(AI+(B3-B2)*D2*.5)/B1
11550 TC=D1+D2
11600 I1=BI*DI^3/12+B1*D1*(YC-D1/2)^2+B2*D2^3/12+B2*D2*(D1+D2-YC-D2/2)^2
11650 IC=II/B1
11700 CLS
11750 GOTO 12602
11800 INPUT "INPUT THICKNESS OF THE CONCRETE SLAB ABOVE THE STEEL DECK = ? IN";D
1
11850 PRINT " "
11900 LPRINT "SLAB ON FORMED STEEL DECK PERPENDICULAR TO THE BEAM"
11950 LPRINT A1$
12000 INPUT "INPUT DEPTH OF THE RIBS-----------------------------= ? IN";D2
12050 PRINT " "
12100 INPUT "INPUT DISTANCE FROM CENTER TO CENTER OF THE RIBS---= ? IN";B1
12150 PRINT " "
12200 INPUT "INPUT TOP CLEAR WIDTH OF THE RIBS---------------= ? IN";B2
12250 PRINT " "
12300 INPUT "INPUT BOTTOM CLEAR WIDTH OF THE RIBS--------------= ? IN";B3
12350 AI=B1*D1+B3*D2
12400 YC=DI/2
12450 IC=D1^3/12
12500 TC=D1+D2
12550 AC=DI
12600 TS=(A1+ABS(B3-B2)*D2*.5)/B1
12602 INPUT "DO YOU WANT A COPY OF THE STEEL DECK DATA Y/N";Z$
12604 IF Z$="Y" THEN 12610 ELSE 12650
12610 LPRINT "THICKNESS OF THE CONCRETE SLAB ABOVE THE STEEL DECK = ";DI;"IN"
12615 LPRINT "DEPTH OF THE RIBS ----------------------------------= ";D2;"IN"
12620 LPRINT "DISTANCE FROM CENTER TO CENTER OF THE RIBS ---------= ";B1;"IN"
12625 LPRINT "TOP CLEAR WIDTH OF THE RIBS ------------------------= ";B2;"IN"
12630 LPRINT "BOTTOM CLEAR WIDTH OF THE RIBS----------------------= ";B3;"IN"
12650 CLS
12700 REM THE FOLLOWING STEPS DESIGN THE COMPOSITE SECTION
12750 PRINT "A-DESIGN THE MOST ECONOMICAL SECTION"
12800 PRINT " "
12850 PRINT "B-REVIEW A SPECIFIC STANDARD SECTION"
12900 PRINT " "
12950 PRINT "C-REVIEW A BUILT-UP SECTION"
13000 PRINT " "
13050 PRINT "D-DESIGN FOR DEPTH RESTRICTION USING WIDE BEAM AND COVER PLATE IF N
ECESSARY"
13100 PRINT A3$
13150 PRINT " "
13200 INPUT "INPUT DESIRED CONDITION  (A) OR (B) OR (C) OR (D)";C$
13250 CLS
13255 IF I$="Y" OR I$="N" THEN 13267
13260 PRINT " "
13265 INPUT "INPUT IS THE BEAM INTERIOR  Y/N  ?";I$
13267 IF I$ ="Y" THEN 13300
13270 IF ZZ > I THEN 13300
13275 INPUT "INPUT THE WIDTH OF SLAB EXTENDING BEYOND THE EDGE OF THE STEEL BEAM
 FLANGE = ? FT";OV
13280 S=S/2+OV
13300 IF C$="A" THEN 14800
13350 IF C$="B" THEN 13500
13400 IF C$="C" THEN 16150
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13500 REM THE FOLLOWING STEPS CHECK A GIVEN STANDARD SECTION
13550 LPRINT "REVIEWING A SPECIFIC STANARD SECTION"
13600 LPRINT A1$
13650 CLS
13660 INPUT "INPUT THE FIRST SUBSCRIPT ";P1
13670 INPUT "INPUT THE SECOND SUBSCRIPT ";P2
13700 FOR I=1 TO 99
13750 IF P1=BB(I,1) THEN M=I :GOTO 13810
13800 NEXT I
13810 FOR J=M TO 99
13820 IF P2=BB(J,2) THEN MMMM=J:M=MMMM:GOTO 13826
13822 IF J=99 THEN 13838
13825 NEXT J
13826 IF P1=BB(MMMM,1) THEN 13840 ELSE M=M+1:GOTO 13810
13838 PRINT "THIS SECTION IS NOT LISTED IN THE  AISC SPECIAL TABLE FOR COMPOSITE
 SECTIONS"
13839 LPRINT "THIS SECTION IS NOT LISTED IN THE  AISC SPECIAL TABLE FOR COMPOSIT
E SECTIONS":END
13840 LPRINT " "
13850 AS=A(M,7):IS=A(M,12):BF=A(M,10):TF=A(M,11):TW=A(M,9):HS=A(M,8):RRT=A(M,6)
13860 YS=HS/2
14500 WS=AS*.2831*12/(1000*S)
14550 GOSUB 34500
14600 INPUT "INPUT TRIAL NO. ?";ZZ
14650 LPRINT "TRIAL NO. ";ZZ
14700 LPRINT "STEEL BEAM   ";"W";P1;"X";P2
14750 GOTO 19900
14800 REM THE FOLLOWING STEPS SELECT THE STEEL BEAM AS IF SHORING WERE TO BE USE
D
14850 REM WEIGHT OF THE STEEL BEAM ASSUMED TO BE 0.007 K/FT
14900 LPRINT "DESIGN THE MOST ECONOMICAL SECTION"
14950 WS=.007
15000 GOSUB 34500
15050 K=(TC-4)*2+1
15100 IF K < 1 THEN K=1
15150 IF K > 5 THEN K=5
15200 K=INT(K)
15250 ST=MT*12/FS(1)
15300 SS=MD*12/FS(1)
15350 ZZ=1
15400 FOR I=1 TO 99
15450 IF ST>A(I,K) THEN M=I :GOTO 15505
15500 NEXT I
15505 IF I=100 THEN M=99
15510 FOR I=1 TO 99
15515 IF SS > A(I,12)*2/A(I,8) THEN M1=I:GOTO 15522
15520 NEXT I
15522 IF I=100 THEN M1=99
15525 IF M < M1 THEN 15550
15530 M=M1
15550 IF M=1 THEN 15700
15600 IF M >=99 THEN M=99 :GOTO 15700
15650 M=M-1
15700 AS=A(M,7):IS=A(M,12):BF=A(M,10):TF=A(M,11):TW=A(M,9):HS=A(M,8):RRT=A(M,6)
15750 YS=HS/2
15800 WS=AS*.2831*12/(1000*S)
15850 GOSUB 34500
15900 PRINT " "
15950 LPRINT "TRIAL NO   ";ZZ
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16050 LPRINT A1$
16100 GOTO 19900
16150 REM THE FOLLOWING STEPS CALCULATE MOMENT OF INERTIA AND CENTROID OF BUILT
UP SECTION
16200 LPRINT "REVIEWING BUILT-UP SECTION"
16250 LPRINT A1$
16300 CLS
16350 INPUT "INPUT SECTION NO. OR DESCRIPTION -----";W$
16400 INPUT "INPUT TRIAL NO. ";ZZ
16450 LPRINT "TRIAL NO.";ZZ
16500 LPRINT "SECTION NO.  ";W$
16550 PRINT "FOR THE UPPER FLANGE"
16600 PRINT  A1$
16650 INPUT "INPUT THE WIDTH ---------------- = ? IN";BF
16700 INPUT "INPUT THE THICKNESS ------------ = ? IN";TF
16750 PRINT "FOR THE LOWER FLANGE"
16800 PRINT  A1$
16850 INPUT "INPUT THE WIDTH ---------------- = ? IN";BF(2)
16900 INPUT "INPUT THE THICKNESS ------------ = ? IN";TF(2)
16950 PRINT "FOR THE WEB"
17000 PRINT  A1$
17050 INPUT "INPUT DEPTH OF THE STEEL SECTION = ? IN";HS
17100 INPUT "INPUT THE THICKNESS ------------ = ? IN";TW
17150 HW=HS-TF-TF(2)
17200 AS=BF*TF+HW*TW+BF(2)*TF(2)
17250 M1=BF*TF*(HS-TF/2)+TW*HW*HS/2+BF(2)*TF(2)^2/2
17300 YS=M1/AS
17350 IS=BF*TF^3/12+BF*TF*(HS-YS-TF/2)^2+TW*HW^3/12+TW*HW*(HS/2-YS)^2+BF(2)*TF(2
)^3/12+BF(2)*TF(2)*(YS-TF(2)/2)^2
17400 IY=(TF*BF^3+HS*TW^3+TF(2)*BF(2)^3)/12
17450 WS=AS*.2831*12/(1000*S)
17500 GOSUB 34500
17550 GOTO 19900
17600 REM THE FOLLOWING STEPS PICK A STANDARD BEAM FOR THE DEPTH RESTRICTION
17650 LPRINT "DESIGN FOR DEPTH RESTRICTION"
17660 ZZ=0
17700 LPRINT A1$
17750 CLS
17800 INPUT "INPUT TOTAL ALLOWABLE DEPTH ( BEAM + SLAB ) = ? IN";HT
17850 HA=HT-TC
17900  HM=L*12/24
17950 IF HT < HM  THEN LPRINT "THE GIVEN DEPTH IS TOO SMALL ,THE MINIMUM ALLOWAB
LE DEPTH =";HM :STOP
18000 K=(TC-4)*2+1
18050 IF K < 1 THEN K=1
18100 IF K > 4 THEN K=4
18150 K=INT(K)
18200 WS=.007
18250 GOSUB 34500
18300 ST=MT*12/FS(1)
18350 FOR I=1 TO 24
18400 IF ST > E(I,K) THEN M5=I :GOTO 18460
18450 NEXT I
18460 IF I=25 THEN M5=24
18500 GOSUB 18700
18550 WS=AS*.2831*12/(1000*S)
18600 GOSUB 34500
18650 GOTO 19900
18700 FOR I=1 TO 24
18750 IF HA >=E(I,6) THEN 18850
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18800 NEXT I
18850 M=I
18900 IF M ) 24 THEN 18950 ELSE 19250
18950 LPRINT "THE GIVEN DEPTH IS TOO SMALL , MINIMUM DEPTH SHOULD BE AT LEAST  "
;E(24,6)+TC+TP;"IN"
19000 PRINT " "
19050 PRINT " "
19100 PRINT "THE GIVEN DEPTH IS TOO SMALL , MINIMUM DEPTH SHOULD BE AT LEAST  ";
E(24,6)+TC+TP;"IN":M=24
19150 INPUT "DO YOU WANT TO CONTINUE WITH THIS DEPTH    ? Y/N ";Z$
19200 IF Z$"Y" THEN 19250 ELSE END
19250 IF ZZ ) 0 THEN 19400
19300 IF M5 ( M THEN 19400
19350 M=M5
19400 AS=E(M,5):IS=E(M,10):BF=E(M,8):TF=E(M,9):TW=E(M,7):HS=E(M,6):YS=HS/2 :RRT=
E(M,12)
19450 ZZ=ZZ+1
19500 LPRINT "TRIAL NO.";ZZ
19550 LPRINT A1$
19600 LPRINT "STEEL BEAM    ";D$(M)
19650 IF TP =0 THEN 19850
19700 PRINT "TOTAL DEPTH=";TC+HS+TP
19750 LPRINT "THICKNESS OF THE COVER PLATE =";TP
19800 LPRINT "TOTAL DEPTH=";TC+HS+TP
19850 RETURN
19900 REM THE FOLLOWING STEPS CALCULATE THE MOMENT OF INERTIA FOR THE TRANSFORME
D SECTION
20000 PRINT " "
20100 CLS
20150 PRINT "TRIAL NO.    ";ZZ
20200 PRINT " "
20250 IF C$="A" THEN PRINT "STEEL BEAM   ";"W";BB(M,1);"X";BB(M,2)
20300 IF C$="C" THEN PRINT "STEEL BEAM    ";W$
20310 IF C$="B" THEN PRINT "STEEL BEAM    ";"W";P1;"X";P2
20350 IF C$="D" THEN PRINT "STEEL BEAM   ";D$(M)
20400 PRINT A1$
20450 GOSUB 39000
20500 IF I$="Y" THEN 20900
20700 B(1)=L+BF :B=B(1)
20750 B(2)=.5*(S*12+BF):IF B(2)(B THEN B=B(2)
20800 B(3)=6*TC+BF+12*OV:IF B(3) ( B THEN B= B(3)
20850 GOTO 21050
20900 B(1)=L*12/4:B=B(1)
20950 B(2)=16*TC+BF:IF B(2)(B THEN B=B(2)
21000 B(3)=S*12:IF B(3)( B     THEN B=B(3)
21050 IF FC/1000 ( 3.5 THEN NN=9:GOTO 21400
21100 IF FC/1000 ( 4' THEN NN=8.5 : GOTO 21400
21150 IF FC/1000 ( 4.5 THEN NN=8 : GOTO 21400
21200 IF FC/1000 ( 5' THEN NN=7.5 : GOTO 21400
21250 IF FC/1000 ( 6' THEN NN=7 : GOTO 21400
21300 IF FC/1000 = 6' THEN NN=6.5 : GOTO 21400
21350 IF FC/1000 )6' THEN NN=6
21400 BE=B/NN
21450 AT=BF+AC+AS
21500 MI=BE*AC*YC+AS*(TC+HS+TP-YS)
21550 YM=MI/AT
21600 IM=IC*BE+AC*BE*(YM-YC)^2+IS+AS*(HS+TC+TP-YM-YS)^2
21650 IF TP=0 THEN YMM=YM:IMM=IM
21700 REM THE FOLLOWING STEPS CALCULATE THE STRESSES
21750 FC(2)=ML*YM*12/(NN*IM)
21800 FS(3)=MT*12*(HS+TC+TP-YM)/IM
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21850 FS(2)=MD*12*(HS+TP-YS)/IS
21900 REM THE NEXT STEP CHECK ASCI FORMULA
21950 SC(ZZ)=(1.35+.35*ML/MO)*IS/YS
22000 FV(2)=V/(HS*TW)
22050 REM THE FOLLOWING STEPS CALCULATE THE DEFLECTION
22100 IF L$="Y" THEN 22300
22150 OO=MD*L^2/(160*IS)
22200 OL(ZZ)=ML*L^2/(160 *IM):GOTO 23900
22300 IF TP ) 0 THEN 23850
22350 FOR I=1 TO N
22400 M1=RTLL*C(I)-WL*S/1000*C(I)^2/2
22410 M2=0
22450 IF I=1 GOTO 22700
22550 FOR J=1 TO I-1
22600 M2=M2+PL(J)*(C(I)-C(J))
22650 NEXT J
22700 MCLL(I)=M1-M2
22750 NEXT I
22800 IF N=1 THEN ERT=.5*C(1)*MCLL(1)*(C(1)/3+L-C(1))+.5*MCLL(1)*(L-C(1))^2*2/3+
WL*S*L^3/24000 :GOTO 23100
22850 FOR I=1 TO N
22900 IF I=1 THEN ERT=.5*C(1)*MCLL(1)*(L-2/3*C(1))+MCLL(1)*(C(2)-C(1))*(L-(C(2)+
C(1))/2)+(MCLL(2)-MCLL(1))*(C(2)-C(1))*.5*((C(2)-C(
1))/3+L-C(2))+WL*S*L^3/24000 :GOTO 23050
22950 IF I= N THEN ERT=ERT+MCLL(N)*(L-C(N))^2/3 :GOTO 23050
23000 ERT=ERT+MCLL(I)*(C(I+1)-C(I))*(L-(C(I+1)+C(I))/2)+(MCLL(I+1)-MCLL(I))*(C(I
+1)-C(I))*.5*((C(I+1)-C(I))/3+L-C(I+1))
23050 NEXT I
23100 ERT=ERT/L
23150 REM THE NEXT STEPS CALCULATE THE ELASTIC MOMENT
23200 IF X(2) ) L/2 THEN XXX=L-X(2) :GOTO 23300
23250 XXX=X(2)
23300 KK=WL*S*L*XXX/2000-WL*S*XXX^2/2000
23350 EM1=-(WL*S*L^3*XXX/24000)+KK*XXX^2/4
23400 IF N=1  THEN EM2=ERT*C(1)
23450 EM2=MCLL(1)*C(1)*(X(2)-2*C(1)/3)/2-ERT*X(2)
23500 FOR I=1 TO N
23550 IF C(I+1) ) X(2) THEN 23600   ELSE 23650
23600 EM(2)=EM(2)+MCLL(I)*(X(2)-C(I)/2)+(X(2)-C(I))/(C(I+1)-C(I))*(MCLL(I+1)-MCL
L(I))*(X(2)-C(I))^2/6 :GOTO 23800
23650 EM2=EM2+MCLL(I)*(C(I+1)-C(I))*(X(2)-(C(I+1)+C(I))/2)+(MCLL(I+1)-MCLL(I))/2
*(C(I+1)-C(I))*((C(I+1)-C(I))/3+X(2)-C(I+1))
23700 IF C(I+1) = X(2) THEN 23800
23750 NEXT I
23800 MEM=-(EM1+EM2)
23850 DL(ZZ)=MEM*12^3/(IM*29000)
23900 REM THE FOLLOWING STEPS CHECK IF THE SECTION IS SAFE
23950 REM THE FOLLOWING STEPS CHECK IF THE SECTION IS ECONOMICAL
24000 XX(1)=(FS(1)- FS(2))/FS(1) :XX=XX(1)
24050 XX(2)=(FS(1)- FS(3))/FS(1) :IF XX(2)( XX THEN XX=XX(2)
24100 XX(3)=(FV(1)-FV(2))/FV(1) :IF XX(3) ( XX THEN XX=XX(3)
24150 OFS(ZZ)=XX
24160 IF ABS(DFS(ZZ-1)+OFS(ZZ)) ( ABS(OFS(ZZ-1))+ABS(OFS(ZZ)) THEN ZZZZ=ZZZZ+1
24200 GOSUB 39550
24250 IF FC(2) ) FC(1) THEN LPRINT "CONCRETE STRESS IS UNSAFE, INCREASE THICKNES
S OR STRENGTH OF THE CONCRETE SLAB"
24252 LPRINT USING "OIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = ###.#
# %";XX*100
24255 IF ZZZZ=2 THEN LPRINT "THIS SECTION IS SAFE AND THE MOST ECONOMICAL":GOTO
 27400
24300 IF C$="A" THEN 24510
24350 IF C$="D" THEN 24900
24360 IF DL(ZZ) )OA THEN LPRINT "OEFLECTION OF THIS SECTION IS GREATER THAN THE
ALLOWABLE , TRY BIGGER SECTION ":GOTO 27400
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24370 IF SC(ZZ) < IM/(HS+TC-YM) THEN LPRINT "SHORING IS REQUIRED, YOU MAY TRY BI
GGER SECTION " :GOTO 27400
24400 IF XX > .1   THEN LPRINT "SECTION IS NOT ECONOMICAL TRY SMALLER SECTION":G
OTO 27400
24450 IF XX > 0 THEN LPRINT "SECTION IS SAFE AND ECONOMICAL " :GOTO 27400
24500 LPRINT "THE SECTION  IS UNSAFE TRY BIGGER SECTION":STOP
24510 IF DL(ZZ) > DA THEN 24550 ELSE 24590
24550 LPRINT "DEFLECTION OF THIS SECTION IS GREATER THAN THE ALLOWABLE , THE PRO
GRAM WILL TRY  THE NEXT BIGGER SECTION":GOTO 24610
24590 IF SC(ZZ) < IM/(HS+TC-YM) THEN 24600 ELSE 24650
24600 LPRINT "SHORING IS REQUIRED, THE PROGRAM WILL TRY THE NEXT BIGGER SECTION
TO AVOID SHORING"
24610 IF MMM > 1 THEN 24615 ELSE 24850
24615 M=MMM:ZZ=ZZ+1:GOTO 15700
24650 IF XX > .05 AND M=99 THEN LPRINT "THIS IS SAFE, IT IS THE SMALLEST SECTION
 IN THE AISC TABLE":GOTO 27400
24655 IF ZZZZ=1 AND XX > 0 THEN ZZZZ=2 :GOTO 24255
24660 IF XX > 0 THEN 24670 ELSE 24750
24670 IF DL(ZZ1-1) > DA OR SC(ZZ1-1) < IM/(HS+TC-YM) THEN ZZZZ=2:GOTO 24255 ELSE
 24700
24700 LPRINT "THIS SECTION IS SAFE, FOR ECONOMY, THE PROGRAM WILL TRY THE NEXT S
MALLER SECTION":MMM=M:M=M+1:ZZ=ZZ+1:GOTO 24705
24705 IF A(M,7) > A(MMM,7) THEN 24710 ELSE 15700
24710 M=M+1 :GOTO 24705
24750 IF ZZZZ=1 THEN LPRINT "THIS SECTION IS UNSAFE ,THE PREVIOUS SECTION IS THE
 BEST, THE PROGRAM WILL          RE-DISPLAY THE PREVIO
US SECTION RESULT":ZZ=ZZ+1:M=MMM :LPRINT "M=";M:GOTO 15700
24800 LPRINT "THIS SECTION IS UNSAFE, THE PROGRAM WILL TRY BIGGER SECTION"
24850 M=M-1  :ZZ=ZZ+1  :GOTO 15700
24900 IF DL(ZZ) > DA THEN 24950 ELSE 24960
24950 LPRINT "DEFLECTION OF THIS SECTION IS GREATER THAN THE ALLOWABLE , THE PRO
GRAM WILL TRY  THE NEXT BIGGER SECTION":GOTO 25450
24960 IF SC(ZZ) < IM/(HS+TC-YM) THEN 25000 ELSE 25010
25000 LPRINT "SHORING IS REQUIRED, THE PROGRAM WILL TRY THE NEXT BIGGER SECTION
TO AVOID SHORING" :GOTO 25450
25010 IF TP >0 THEN 25400
25020 IF ZZZZ=1 AND XX > 0 THEN ZZZZ=2 GOTO 24255
25030 IF M=24 AND XX > 0 THEN LPRINT "SECTION IS SAFE ,IT IS THE SMALLEST SECTIO
N IN THE AISC TABLE":GOTO 28200
25100 IF XX > 0 THEN 25110 ELSE 25210
25110 IF DL(ZZ1-1) > DA OR SC(ZZ1-1) < IM/(HS+TC-YM) THEN ZZZZ=2 :GOTO 24255
25200 LPRINT "THIS SECTION IS SAFE , FOR ECONOMY , THE PROGRAM WILL TRY THE NEXT
 SMALLER SECTION":MMM=M:M=M+1
25202 IF E(M,5) >  E(MMM,5) THEN 25204 ELSE 25300
25204 M=M+1 :GOTO 25202
25210 IF ZZZZ=1 THEN 25250 ELSE 25255
25250 LPRINT "THIS SECTION IS UNSAFE , THE PREVIOUS SECTION IS SAFE AND ECONOMIC
AL, THE PROGRAM WILL        RE-DISPLAY THE  PREVIOUS
SECTION RESULT":ZZ=ZZ+1:M=MMM :GOSUB 19400
25252 GOTO 19900
25255 IF XX < 0 THEN 25450
25300 GOSUB 19400
25310 WS=AS*.2831*12/(1000*S)
25350 GOTO 19900
25400 IF XX > 0 THEN LPRINT "SECTION IS SAFE AND ECONOMICAL":GOTO 26600
25450 IF HA >= E(M-1,6) THEN 25455 ELSE 25600
25455 IF TP=0 AND XX < 0 THEN LPRINT "THIS SECTION IS UNSAFE , THE PROGRAM WILL
TRY THE NEXT BIGGER SECTION "
25460 IF MMM > 1 THEN 25470 ELSE 25500
25470 M=MMM :ZZ=ZZ+1 :GOSUB 19400
```

```
25480 GOTO :19900
25500 M=M-1:GOSUB 19400
25550 GOTO 19900
25600 IF TP > 0 THEN 25750
25650 TP=.25
25700 HA=HA-.25 :GOTO 25850
25750 TP=TP+.125
25800 HA=HA-.125
25850 IF TP >=1.6 THEN LPRINT "THE GIVEN DEPTH IS TOO SMALL " :END
25900 LPRINT "THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICK
NESS          =";TP;"IN"
25950 GOSUB 18700
26000 BT=E(M,11)
26050 M1=AS*(HS/2+TP)+BT*TP^2/2
```

```
26100 AS=AS+BT*TP
26150 WS=AS*.2831*12/(1000*S)
26200 YS=M1/AS
26250 IS=IS+E(M,5)*(HS/2+TP-YS)^2+BT*TP^3/12+BT*TP*(YS-TP/2)^2
26300 GOSUB 34500
26350 PRINT "TRAIL NO. ";ZZ
26400 PRINT " "
26450 PRINT "STEEL BEAM  ";O$(M) ;"     ";"WITH COVER PLATE ";TP;"IN"
26500 GOSUB 39000
26550 GOTO 21450
26600 IF TP )  0  THEN 26650 ELSE 27400
26650 REM THE FOLLOWING STEPS CALCULATE THE LENGTH OF THE COVER PLATE
26700 LPRINT "COVER PLATE"
26750 LPRINT A1$
26800 MPL=IMM*FS(1)/((TC+HS-YMM)*12)
26850 FOR I=1 TO 4*L1
26900 IF XP(1) )0 THEN 27100
26950 IF MPL (= BM(I) THEN 27000 ELSE 27250
27000 XP(1)=I/4-.25
27050 LPRINT "LEFT THEORETICAL CUT OFF POINT ------------------=";XP(1);"FT";"FR
OM THE LEFT SUPPORT":GOTO 27250
27100 IF BM(I) (=MPL THEN 27150 ELSE 27250
27150 XP(2)=L-I/4
27200 LPRINT "RIGHT THEORETICAL CUT OFF POINT ------------------=";XP(2);"FT";"F
ROM THE RIGHT SUPPORT":GOTO 27300
27250 NEXT I
27300 LPRINT "WIOTH OF THE COVER PLATE -------------------=";BT;"IN"
27350 LPRINT "NOTE : DEVELOPING LENGTH MUST BE ADDED TO BOTH SIOES"
27400 REM THE FOLLOWING STEPS CHECK IF LATERAL SUPPORT IS REOUIRED
27450 IF C$="B" OR C$="C" THEN 27500 ELSE 27600
27500 RRT1=BF*TF+(HS-2*TF)*TW/6
27550 RRT=SOR(IY/(2*RRT1))
27600 LU(1)=RRT*SOR(170000'/FS(2))/12
27650 LO=RRT*SOR(510000'/FY)/12
27700 IF LU(1)) LD THEN LU=LU(1):GOTO 28050
27750 LU(1)=RRT*SOR(1530000'/FY*(2/3-FS(2)/FY))/12
28000 LPRINT " "
28050 GOSUB 39350
28100 REM THE FOLLOWING STEPS CALCULATE THE SHEAR CONNECTORS
28150 PRINT " "
28200 CLS
28250 PRINT "****************************************************************"
28300 PRINT "ALLOWABLE HORIZONTAL SHEAR LOAD FOR ONE CONNECTOR (O),KIPS"
28350 PRINT A4$
28400 PRINT "                                 STRENGTH OF THE CONCRETE "
28450 PRINT "                              (FC)=   3.0      3.5    )=4.0  KIPS"
28500 PRINT A4$
28550 PRINT "A-(1/2)IN OIM X(2.0)IN HEADEO STUD    5.1      5.5      5.9"
28600 PRINT "    ";A2$
28650 PRINT "B-(5/8)IN OIM X(2.5)IN HEAOEO STUD    8.0      8.6      9.2"
28700 PRINT "    ";A2$
28750 PRINT "C-(3/4)IN OIM X(3.0)IN HEAOED STUO    11.5     12.5     13.3"
28800 PRINT "    ";A2$
28850 PRINT "D-(7/8)IN OIM X(3.5)IN HEAOED STUO    15.6     16.8     18.0"
28900 PRINT A4$
28950 PRINT " "
29000 INPUT"INPUT THE DESIRED CONNNECTOR TYPE (A) (B) (C) OR (O)?";ST$
29050 IF ST$="A" THEN S1=1
29100 IF ST$="B" THEN S1=2
```

```
29150 IF ST$="C" THEN S1=3
29200 IF ST$="D" THEN S1=4
29250 IF FC/1000 < 3.5 THEN K1=3 :GOTO 29400
29300 IF FC/1000 < 4   THEN K1=4 :GOTO 29400
29350 K1=5
29400 SP1=6*F(S1,1)
29450 SP2=8*TC
29500 IF TF*2.5 <= F(S1,1) THEN LPRINT "USE STUDS WITH SMALLER DIAMETER, MAX. DI
AMETER =";TF*2.5;"IN":PRINT "USE STUDS WITH SMALLER
 DIAMETER, MAX. DIAMETER =";TF*2.5;"IN":GDTD 29860
29550 VH(1)=.85*FC*AC*B/2000
29600 VH(2)=AS*FY/2
29650 IF VH(1) <VH(2) THEN VH=VH(1) :GOTO 29750
29700 VH=VH(2)
29750 HC=F(S1,2)
29760 IF A$="B" OR A$="C" THEN HC=D2+1.5
29800 DM=F(S1,1)
29805 IF A$="B" CR A$="C" THEN 29900
29810 IF HC > TC-1 THEN 29640 ELSE 29900
29840 PRINT " "
29850 LPRINT "CHDDSE ANOTHER STUD WITH SHDRTER LENGTH, MAX. LENGTH =";TC-1;"IN":
PRINT "CHODSE ANOTHER STUD WITH SHDRTER LENGTH, MAX
. LENGTH =";TC-1;"IN":GDTO 29860
29852 PRINT " "
29854 PRINT A3$
29860 INPUT "DO YOU WANT TO CONTINUE    Y/N ";Z$
29870 IF Z$="Y" THEN 28200 ELSE STOP
29900 IF A$="A" THEN Q1=F(S1,K1):GOTO 30500
29910 IF DM > .75 THEN PRINT "MAXIMUM ALLOWABLE STUD DIAMETER TO BE USED WITH ME
TAL DECK IS ";.75;"IN":GOTO 29860
29950 IF A$="B" THEN 30000 ELSE 30200
30000 F1=.6*B3/D2*(HC/D2-1)
30050 IF F1 < 1 THEN 30150
30100 F1=1
30150 Q1=F1*F(S1,K1):GDTO 30500
30200 INPUT "INPUT HOW MANY STUD CONNECTDRS IN ONE RIB ";NR
30250 SP2=16
30300 F1=.85*B3/(SQR(NR)*D2)*(HC/D2-1)
30350 IF F1 < 1 THEN 30450
30400 F1=1
30450 Q1=F1*F(S1,K1)
30500 NS=VH/Q1 :NSS=NS :SP3=12*L/(NS)
30550 IF SP3 > SP2 THEN NS=L*12/(2*SP2)
30555 IF SP3*2 < SP1 THEN LPRINT "USE STUDS WITH BIGGER CAPACITY ":PRINT "USE ST
UDS WITH BIGGER CAPACITY":GOTD 29860
30600 IF L$="N" THEN 31650
30650 R5 =IM*YS/((HS+TP+TC-YM)*IS)
30700 FDR I=1 TO N
30750 M1=RT*C(I)-WT*C(I)^2/2
30800 M2=0
30850 IF I=1 GDTO 31050
30900 FOR J=1 TO I-1
30950 M2=M2+P(J)*(C(I)-C(J))
31000 NEXT J
31050 MCL(I)=M1-M2
31100 R10(I)=MCL(I)*R5/MT
31150 IF R10(I) >  1 THEN  31350
31200 IF C(I) > X THEN 31300
31250 N(I)=NS*C(I)/X :GDTD 31600
31300 N(I)=NS*(L-C(I))/X :GOTO 31600
31350 N(I)=NS*(MCL(I)*R5/MT-1)/(R5-1)
```

```
31400 IF C(I) ) X THEN 31550
31450 IF NS*C(I)/X ) N(I) THEN 31500  ELSE 31600
31500 N(I)=NS*C(I)/X:GOTO 31600
31550 IF NS*(L-C(I))/X ) N(I) THEN N(I)=NS*(L-C(I))/X
31600 NEXT I
31650 NS=INT(NS)+1
31700 CLS
31750 PRINT A2$
31800 PRINT "           SHEAR CONNECTORS  "
31850 PRINT A2$
31900 IF L$="Y" THEN 32650
31950 PRINT "TOTAL NO. OF SHEAR CONNECTORS--------------------=";2*NS
32000 PRINT "NO. OF  SHEAR CONNECTORS TO BE USED EACH SIDE----=";NS
32100 PRINT "SHEAR RESISTANCE OF EACH SHEAR CONNECTOR---------=";F(S1,K1);"KIPS"
32110 IF A$="B" OR A$="C" THEN PRINT "STUD CONNECTORS LENGTH  ----------------
---=";HC;"IN"
32150 PRINT A2$
32200 INPUT "DO YOU WANT A COPY OF SHEAR CONNECTOR DATA ? Y/N";Z$
32250 IF Z$="Y" THEN 32300 ELSE 33950
32300 LPRINT A2$
32350 LPRINT "          SHEAR CONNECTORS  "
32400 LPRINT A2$
32450 LPRINT "TOTAL NO. OF SHEAR CONNECTORS--------------------=";2*NS
32500 LPRINT "NO. OF  SHEAR CONNECTORS TO BE USED EACH SIDE----=";NS :GOTO 33900
32550 IF SP3 ( SP1 THEN LPRINT "THE DISTANCE BETWEEN THE STUDS IS TOO SMALL, USE
 STUDS WITH BIGGER CAPACITY ":GOTO 28300
32600 LPRINT "SHEAR RESISTANCE OF EACH SHEAR CONNECTOR---------=";F(S1,K1);"KIPS
"
32610 IF A$="B" OR A$="C" THEN LPRINT "STUD CONNECTORS LENGTH  ---------------
-----=";HC;"IN"
32650 FOR I=1 TO N+1
32700 IF I= N+1 THEN C(I)=L
32750 IF I=1 AND C(I) )X THEN 32850
32800 IF C(I-1) ( X AND C(I) ) X THEN  32850 ELSE 32950
32850 PRINT "NO. OF STUDS FROM POINT ";C(I-1)"FT  TO POINT ";X"FT  ="INT(NS-N(I-
1))+1
32900 PRINT "NO. OF STUDS FROM POINT ";X"FT  TO POINT ";C(I)"FT  ="INT(NS-N(I))+
1:SP3=ABS((X-C(I))*12*2/(NS-N(I))):GOTO 33000
32950 PRINT "NO. OF STUDS FROM POINT ";C(I-1)"FT  TO POINT";C(I)"FT  =";INT(ABS(
N(I)-N(I-1)))+1:SP3=ABS((C(I-1)-C(I))*12*2/(N(I)-N(
I-1)))
33000 IF SP3*2  ( SP1 THEN PRINT "THE DISTANCE BWTWEEN THE STUDS IS TOO SMALL, U
SE STUDS WITH BIGGER CAPACITY":GOTO 28200
33050 NEXT I
33100 PRINT "SHEAR RESISTANCE OF EACH SHEAR CONNECTOR---------=";F(S1,K1);"KIPS"
33110 IF A$="B" OR A$="C" THEN PRINT "STUD CONNECTORS LENGTH  ----------------
---=";HC;"IN"
33150 PRINT A3$
33200 INPUT "INPUT DO YOU WANT A COPY OF THE SHEAR CONNECTOR DATA Y/N";Z$
33250 IF Z$="Y" THEN 33300 ELSE 33950
33300 LPRINT A2$
33350 LPRINT "          SHEAR CONNECTORS  "
33400 LPRINT A2$
33450 FOR I=1 TO N+1
33500 IF I= N+1 THEN C(I)=L
33550 IF I=1 AND C(I) )X THEN 33650
33600 IF C(I-1) ( X AND C(I) ) X THEN  33650 ELSE 33750
33650 LPRINT "NO. OF STUDS FROM POINT ";C(I-1)"FT  TO POINT ";X"FT  =";INT(NS-N(
I-1))+1:SP3=(NS-N(I-1))/(C(I-1)-X)
33700 LPRINT "NO. OF STUDS FROM POINT ";X"FT  TO POINT ";C(I)"FT  =";INT(NS-N(I)
)+1:SP3=(NS-N(I))/(X-C(I)):GOTO 33850
33750 LPRINT "NO. OF STUDS FROM POINT ";C(I-1)"FT  TO POINT";C(I)"FT  =";INT(ABS
(N(I)-N(I-1)))+1:SP3=ABS(N(I)-N(I-1))/(C(I-1)-C(I))

33800 IF SP3 ) SP1 THEN LPRINT "THE DISTANCE BETWEEN THE STUDS IS TOO SMALL, USE
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 STUDS WITH BIGGER CAPACITY":GOTO 28200
33850 NEXT I
33900 LPRINT "SHEAR RESISTANCE OF EACH SHEAR CONNECTOR----------=";F(S1,K1);"KIPS
"
33910 IF A$="B" OR A$="C" THEN LPRINT "STUD CONNECTORS LENGTH  ----------------
-----=";HC;"IN"
33950 LPRINT A4$
34000 PRINT " "
34050 CLS
34100 C=1
34150 INPUT "INPUT DO YOU HAVE ANOTHER LOADING CASE ";Z$
34200 IF Z$="Y" THEN 34250 ELSE 34450
34250 TP=0 :MMM=0
34300 C=C+1
34350 CLS
34400 GOTO 4600
34450 END
34500 REM THE FOLLOWING STEPS CALCULATE THE BENDING MOMENT
34550 WD=TS*WC/12000+WS
34600 IF L$="N" THEN 37550
34650 REM THE FOLLWING STEPS CALCULATE THE REACTION
34700 IF WL <=0 THEN WLL=-10
34750 IF WLL < 0 THEN WL=1E-10 :WD=WS
34800 WT=(WD+WL/1000)*S
34850 FOR Z=1 TO 3
34900 IF Z=1 THEN  34950 ELSE 35200
34950 FOR I=1 TO N
35000 P(I)=PD(I)
35050 NEXT I
35100 W(Z)=WD*S
35150 GOTO 35700
35200 IF Z=2 THEN 35250 ELSE  35500
35250 FOR I=1 TO N
35300 P(I)=PL(I)
35350 NEXT I
35400 W(Z)=WL*S/1000
35450 GOTO 35700
35500 FOR I=1 TO N
35550 P(I)=PD(I)+PL(I)
35600 NEXT I
35650 W(Z)=WT
35700 R1=W(Z)*L/2
35750 R2=0
35800 PT=0
35850 FOR I=1 TO N
35900 R2=R2+P(I)*(L-C(I))/L
35950 PT=PT+P(I)
36000 NEXT I
36050 RT(1)=R1+R2 :RT=RT(1)
36100 IF Z < 3 THEN 36300
36150 RT(2)=PT+W(Z)*L-RT(1)
36200 IF RT(1) >RT(2) THEN V=RT(1) :GOTO 36300
36250 V=RT(2)
36300 REM THE FOLLOWING STEPS CALCULATE POINT OF MAX MOMENT
36350 IF RT > W(Z)*C(1) THEN 36550
36400 X=RT/W(Z)
36450 MM(Z)=RT*X-W(Z)*X^2/2
36500 GOTO 37300
36550 PT=0
36600 FOR J=1 TO N
36650 PT=PT+P(J)
36700 IF RT-W(Z)*C(J)-PT <=0 THEN X=C(J) :GOTO 37000
36750 X=(RT-PT)/W(Z)
36800 IF J=N THEN 37000
```

```
36850 IF X )C(J+1) THEN 36950
36900 GOTO 37000
36950 NEXT J
37000 MU=RT*X-W(Z)*X^2/2
37050 MN=0
37100 FOR K=1 TO J
37150 MN=MN+P(K)*(X-C(K))
37200 NEXT K
37250 MM(Z)=MU-MN
37300 IF Z=1 THEN MO=MM(Z) :RTLO=RT:X(1)=X:GOTO 37450
37350 IF Z=2 THEN  ML=MM(Z) :RTLL=RT:X(2)=X:GOTO 37450
37400 MT=MM(Z)
37450 NEXT Z
37500 GOTO 37900
37550 ML=WL*S*L^2/8000
37600 MO=WO*S*L^2/8
37650 MT=MO+ML
37700 V=(WO+WL/1000)*S*L/2
37750 WT=(WL/1000+WO)*S
37800 RT=V
37850 X=L/2
37900 REM THE FOLLOWING  STEPS CALCULATE THE MOMENT AT 0.25 FT INTERVALS
37950 IF TP ) 0 THEN 38000 ELSE 38900
38000 J=1
38050 FOR I=.25 TO L1 STEP  .25
38100 II=4*I
38150 IF L$="N" THEN 38250
38200 IF I )C(1) THEN 38350
38250 BM(II)=RT*I-WT*I^2/2
38300 GOTO 38850
38350 M1=RT*I-WT*I^2/2
38400 MC=0
38450 FOR K=1 TO J
38500 MC=MC+P(K)*(I-C(K))
38550 NEXT K
38600 BM(II)=M1-MC
38650 I1=I+1
38700 IF I1 )C(J+1) THEN 38750 ELSE 38850
38750 IF J =N THEN 38850
38800 J=J+1
38850 NEXT I
38900 RETURN
38950 PRINT A2$
39000 PRINT A2$
39050 PRINT "            MAXIMUM MOMENT AND SHEAR                    "
39100 PRINT A2$
39150 PRINT USING "MAXIMUM BENDING MOMENT ----------------------------=######.##
 KIPS FT";MT
39200 PRINT USING "MAXIMUM SHEARING FORCE ----------------------------=######.##
KIPS";V
39250 PRINT A2$
39300 RETURN
39350 IF LU )L THEN LPRINT "BEAM NEED NOT BE LATERALLY SUPPORTED DURING CONSTRUC
TION":GOTO 39500
39400 LPRINT USING "BEAM SHOULD BE LATERALLY SUPPORTED EVERY   ####.## FT DURING
 CONSTRUCTION";LU
39450 LPRINT A2$
39500 RETURN
39550 PRINT "          ACTUAL STRESSES AND DEFLECTION "
39600 PRINT A2$
39650 PRINT USING "STRESS  AT THE TOP FIBER OF THE CONCRETE SLAB------###.## KSI
   ";FC(2)
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39700 PRINT USING "STRESS AT THE TOP FIBER OF THE STEEL BEAM ---------=###.## KSI
";FS(2)
39750 PRINT USING "STRESS AT THE BOTTOM FIBER OF THE STEEL BEAM------=###.## KSI
";FS(3)
39800 PRINT USING "SHEAR STRESS IN THE WEB OF THE STEEL BEAM ---------=###.## KSI
";FV(2)
39810 IF L$="Y" THEN 39900
39850 PRINT USING "DEFLECTION DUE TO DEAD LOAD------------------------=###.## IN"
;DD
39900 PRINT USING "DEFLECTION DUE TO LIVE LOAD -----------------------=###.## IN"
;DL(ZZ)
39950 PRINT A2$
40000 PRINT "            REMARKS                    "
40050 PRINT A2$
40100 IF FC(2) > FC(1) THEN PRINT "CONCRETE STRESS IS UNSAFE, INCREASE THICKNESS
 OR STRENGTH OF THE CONCRETE SLAB"
40150 PRINT USING "DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = ###.##
 %";XX*100
40155 IF ZZZZ=2 THEN PRINT "THIS SECTION IS SAFE AND THE MOST ECONOMICAL":GOTO
40950
40200 IF C$="A" THEN 40405
40250 IF C$="D" THEN 40610
40260 IF DL(ZZ) > DA THEN 40261 ELSE 40270
40261 PRINT "DEFLECTION OF THIS SECTION IS GREATER THAN THE ALLOWABLE":GOTO 4095
0
40262 INPUT "DO YOU WANT TO CONTINUE    Y/N ";Z$
40264 IF Z$="Y" THEN 40950 ELSE STOP
40270 IF SC(ZZ) < IM/(HS+TC+TP-YM) THEN PRINT "SHORING IS REQUIRED, YOU MAY TRY
BIGGER SECTION " :GOTO 40950
40300 IF XX > .1   THEN PRINT "SECTION IS NOT ECONOMICAL TRY SMALLER SECTION":GO
TO 40950
40350 IF XX > 0 THEN PRINT "SECTION IS SAFE AND ECONOMICAL":GOTO 40950
40400 PRINT "THE SECTION  IS UNSAFE TRY BIGGER SECTION":GOTO 40950
40405 IF DL(ZZ) > DA THEN 40410 ELSE 40415
40410 PRINT "DEFLECTION OF THIS SECTION IS GREATER THAN THE ALLOWABLE , THE PROG
RAM WILL TRY  THE NEXT BIGGER SECTION":GOTO 40950
40415 IF SC(ZZ) < IM/(HS+TC+TP-YM) THEN PRINT "SHORING IS REQUIRED, THE PROGRAM
WILL TRY THE NEXT BIGGER SECTION TO AVOID SHORING"
:GOTO 40950
40450 IF XX > .05 AND M=99 THEN PRINT "THIS IS SAFE, IT IS THE SMALLEST SECTION
IN THE AISC TABLE":GOTO 40950
40455 IF ZZZZ=1 AND XX >0 THEN ZZZZ=2 :GOTO 40155
40460 IF XX > 0 THEN 40480 ELSE 40550
40480 IF ZZ=1 THEN ZZ1=2 :GOTO 40495
40490 ZZ1=ZZ
40495 IF DL (ZZ1-1) > DA OR SC(ZZ1-1) < IM/(HS+TC+TP-YM) THEN ZZZZ=2 :GOTO 40155
40500 PRINT "THIS SECTION IS SAFE, FOR ECONOMY, THE PROGRAM WILL TRY THE NEXT SM
ALLER SECTION ":GOTO 40950
40550  IF ZZZZ=1 THEN PRINT "THIS SECTION IS UNSAFE, THE PREVIOUS SECTION IS THE
 BEST, THE PROGRAM WILL      RE-DISPLAY THE PREVIOU
S SECTION RESULTS":GOTO 40950
40600 PRINT "THIS SECTION IS UNSAFE, THE PROGRAM WILL TRY BIGGER SECTION":GOTO 4
0950
40610 IF DL(ZZ) > DA THEN 40615 ELSE 40617
40615 PRINT "DFLECTION OF THIS SECTION IS GREATER THAN THE ALLOWABLE , THE PROGR
AM WILL TRY  THE NEXT BIGGER SECTION":GOTO 40950
40617 IF SC(ZZ) < IM/(HS+TC+TP-YM) THEN 40620 ELSE 40625
40620 PRINT "SHORING IS REQUIRED, THE PROGRAM WILL TRY THE NEXT BIGGER SECTION T
O AVOID SHORING" :GOTO 40950
40625 IF TP > 0 THEN 40750
40627 IF ZZZZ=1 AND XX > 0 THEN ZZZZ=2:GOTO 40155
40628 IF M=24 AND XX > 0 THEN PRINT "SECTION IS SAFE ,IT IS THE SMALLEST SECTION
 IN THE AISC TABLE":GOTO 40950
40630 IF XX > 0 THEN  40632 ELSE 40645
40632 IF ZZ=1 THEN ZZ1=2 :GOTO 40636
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40634 ZZ1=ZZ
40636 IF DL(ZZ1-1) ) DA OR SC(ZZ1-1) ( IM/(HS+TC+TP-YM) THEN ZZZZ=2 :GOTO 40155
40640 PRINT "THIS SECTION IS SAFE,FOR ECONOMY , THE PROGRAM WILL TRY THE NEXT SM
ALLER SECTION":GOTO 40950
40645 IF ZZZZ=1 THEN LPRINT "THIS SECTION IS UNSAFE, THE PREVIOUS SECTION IS SAF
E AND ECONOMICAL, THE PROGRAM WILL RE-DISPLAY THE P
REVIOUS SECTION RESULT":GOTO 40950
40650 IF XX ( 0 THEN 40755
40700 PRINT "THIS SECTION IS NOT ECONOMICAL THE MACHINE WILL TRY SMALLER SECTION
":GOTO 40950
40750 IF XX ) 0 THEN PRINT "SECTION IS SAFE AND ECONOMICAL":GOTO 40950
40755 IF HA ) =E(M-1,6) THEN 40760 ELSE 40800
40760 IF TP =0 AND XX (0 THEN PRINT "THIS SECTION IS UNSAFE , THE PROGRAM WILL T
RY THE NEXT BIGGER SECTION":GOTO 40950
40800 IF TP )=1.5 AND XX ( 0 THEN PRINT "THE GIVEN DEPTH IS TOO SMALL":GOTO 4100
0
40850 IF TP=0 THEN PRINT "THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLAT
E WITH THICKNESS =";.25;"IN" :GOTO 40950

40900 PRINT "THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKN
ESS        =";TP+.125 ;"IN"
40950 PRINT A3$
41000 INPUT "DO YOU NEED A COPY OF THE ACTUAL STRESSES ? Y/N";Z$
41050 IF Z$="Y" THEN 41100 ELSE 42500
41100 LPRINT A2$
41150 LPRINT "           MAXIMUM MOMENT AND SHEAR                    "
41200 LPRINT A2$
41250 LPRINT USING "MAXIMUM BENDING MOMENT ----------------------------=######.##
  KIPS FT";MT
41300 LPRINT USING "AT DISTANCE ---------------------------------------=######.##
 FT";X
41350 LPRINT USING "MAXIMUM SHEARING FORCE ----------------------------=######.##
 KIPS";V
41400 LPRINT A2$
41450 LPRINT "           SECTION PROPERTIES  "
41500 LPRINT A2$
41550 LPRINT USING "EFFECTIVE SLAB WIDTH-------------------------------=######.#
 IN";B
41600 LPRINT USING "DISTANCE FROM THE TOP OF CONCRETE SLAB TO CENTROID=######.#
 IN";YM
41650 LPRINT USING "TRANSFORMED MOMENT OF INERTIA----------------------=######.##
 IN^4";IM
41700 LPRINT A2$
41750 LPRINT "           ACTUAL STRESSES AND DEFLECTION "
41800 LPRINT A2$
41850 LPRINT USING "STRESS  AT THE TOP FIBER OF THE CONCRETE SLAB-----=###.## KS
I";FC(2)
41900 LPRINT USING "STRESS AT THE TOP FIBER OF THE STEEL BEAM ---------=###.## KS
I";FS(2)
41950 LPRINT USING "STRESS AT THE BOTTOM FIBER OF THE STEEL BEAM-------=###.## KS
I";FS(3)
42000 LPRINT USING "SHEAR STRESS IN THE WEB OF THE STEEL BEAM ---------=###.## KS
I";FV(2)
42010 IF L$="Y" THEN 42100
42050 LPRINT USING "DEFLECTION DUE TO DEAD LOAD-----------------------=###.## IN
";DD
42100 LPRINT USING "DEFLECTION DUE TO LIVE LOAD ----------------------=###.## IN
";DL(ZZ)
42150 LPRINT A2$
42200 LPRINT "           REMARKS                 "
42250 LPRINT " "
42500 PRINT "  "
42550 RETURN
```

```
42600 REM THE FOLLOWING STEPS DESIGN THE SLAB
42650 INPUT "INPUT HOW MANY SLAB SPANS DO YOU HAVE";NSL
42700 IF NSL=1 THEN 42750 ELSE 43050
42750 DEP(1)=S*12/20
42800 FF=DEP(1)
42850 GOTO 44000
42900 VSL=SQR(FC)*2*12*(FF-.75)*.85/1000
42950 IF S*WTS/2 ) VSL THEN FF=FF+.5:GOTO 44200
43000 RETURN
43050 INPUT "ARE THE SLAB SPANS EQUAL ? Y/N";Z$
43100 CLS
43150 IF Z$="Y" THEN 43500
43200 FOR I=1 TO NSL
43250 PRINT "SLAB SPAN NO. ";I
43300 PRINT " "
43350 INPUT "INPUT LENGTH = ? FT";S(I)
43400 NEXT I
43450 GOTO 43650
43500 FOR I=1 TO NSL
43550 S(I)=S
43600 NEXT I
43650 FOR I=1 TO NSL
43700 DEP(I)=S(I)*12/24
43750 NEXT I
43800 FF=0
43850 FOR I=1 TO NSL
```

```
43900 IF OEP(I) > FF THEN FF=OEP(I)
43950 NEXT I
44000 FFF=INT(FF)+.5
44050 IF FFF=FF+.5 THEN 44200
44100 IF FFF < FF THEN FFF=FFF+.5
44150 FF=FFF
44200 LPRINT "THICKNESS OF THE SLAB =";FF;"IN"
44250 PRINT "THICKNESS OF THE SLAB =";FF;"IN"
44300 TC=FF
44350 WOS=FF*WC*1.4/12000
44400 WLS=WL*1.7/1000
44450 WTS=WOS+WLS
44500 IF NSL=1 THEN 42900
44550 IF NSL=2 THEN 44600 ELSE 45000
44600 MS=WTS*(S(1)^3+S(2)^3)/(8*(S(1)+S(2)))
44650 RS(1)=WTS*S(1)/2+MS/S(1)
44700 RS(2)=WTS*S(2)/2+MS/S(2)
44750 VSL=SQR(FC)*2*12*(FF-.75)*.85/1000
44800 FOR I=1 TO 2
44850 IF RS(I) > VSL THEN FF=FF+.5 :GOTO 44200
44900 NEXT I
44950 RETURN
45000 GOSUB 46050
45050 FOR I=1 TO NNN
45100 MS(I)=0
45150 FOR K=1 TO NNN
45200 MS(I)=MS(I)+G(I,K)*ERS(K+1)*6
45250 NEXT K
45350 NEXT I
45400 VSL=SQR(FC)*2*12*(FF-.75)*.85
45450 FOR I=1 TO NNN
45550 REM RS IS THE SHEAR FORCE AT LEFT AND RIGHT SIDES OF THE SLAB
45600 RS(1)=WTS*S(I)/2+(MS(I)-MS(I-1))/S(I)
45700 RS(2)=WTS*S(I+1)/2+(MS(I)-MS(I+1))/S(I+1)
45800 FOR J=1 TO 2
45850 IF RS(J) > VSL/1000  THEN FF=FF+.5   :GOTO 44200
45900 NEXT J
45950 NEXT I
46000 RETURN
46050 REM THE FOLLOWING STEPS CALCULATE MOMENT BY THE THREE-MOMENT METHOD
46100 FOR I=1 TO NSL
46150 ER(I)=S(I)^3*WTS/24
46200 NEXT I
46250 FOR I=2 TO NSL
46300 ERS(I)=ER(I)+ER(I-1)
46400 NEXT I
46450 NNN=NSL-1
46500 FOR I=1 TO NNN
46550 IF I<>1 THEN 46700
46600 G(1,1)=2*(S(1)+S(2))
46650 G(1,2)=S(2) :GOTO 47000
46700 IF I <> NNN THEN 46850
46750 G(I,I-1)=S(I)
46800 G(I,I)=2*(S(I)+S(I+1)) :GOTO 47000
46850 G(I,I-1)=S(I)
46900 G(I,I)=2*(S(I)+S(I+1))
46950 G(I,I+1)=S(I+1)
```

```
47000 NEXT I
47350 REM THE FOLLOWING STEPS SOLVE (N) EQUATIONS IN (N) UNKNOWNS
47400 REM WHEN IO(I,1)=0 IDENTIFIES THE I-TH ROW AND COLUMN IS USED
47450 FOR I=1 TO NNN
47500 IO(I,1)=0
47550 NEXT I
47600 II=0
47650 AM=-1
47700 REM AM MEMORIZES THE MAX VALUE OF (ABS) OVER THE SEARCHED ELEMENTS
47750 FOR I=1 TO NNN
47800 IF IO(I,1) () 0 THEN 48150
47850 FOR J=1 TO NNN
47900 TPP=ABS(G(I,J))
47950 IF ID(J,1) ()0 THEN 48100
48000 IF TPP ( AM THEN 48100
48050 IR=I :IC=J:AM=TPP
48100 NEXT J
48150 NEXT I
48200 IF AM (0 THEN 49850
48250 IF AM=0 THEN 49950
48300 ID (IC,1)=IR
48350 IF IC=IR THEN 48750
48400 FOR J=1 TO NNN
48450 TPP=G(IR,J)
48500 G(IR,J)=G(IC,J)
48550 G(IC,J)=TPP
48600 NEXT J
48650 II=II+1
48700 IO(II,2)=IC
48750 PV=G(IC,IC)
48800 G(IC,IC)=1
48850 FOR J=1 TO NNN
48900 G(IC,J)=G(IC,J)/PV
48950 NEXT J
49000 FOR I=1 TO NNN
49050 IF I=IC THEN 49350
49100 TPP=G(I,IC)
49150 G(I,IC)=0
49200 FOR J=1 TO NNN
49250 G(I,J)=G(I,J)-G(IC,J)*TPP
49300 NEXT J
49350 NEXT I
49400 GOTO 47650
49450 IC=ID(II,2)
49500 IR=IO(IC,1)
49550 FOR I=1 TO NNN
49600 TPP=G(I,IR)
49650 G(I,IR)=G(I,IC)
49700 G(I,IC)=TPP
49750 NEXT I
49800 II=II-1
49850 IF II () 0 THEN 49950
49900 RETURN
49950 LPRINT "THE SYSTEM IS SINGULAR"
50000 REM THESE ARE THE DATA A(I,J) AND B4(I) FOR THE MOST ECONOMIC SECTION
50050 DATA 36,170
50100 DATA 713,731,748,765,781,3.04,50,36.17,.68,12.03,1.1,10500
```

```
50150 DATA 36,160
50200 DATA 670,686,702,718,733,3.02,47,36.1,.65,12,1.02,9750
50250 DATA 36,150
50300 DATA 628,644,659,674,688,2.99,44.2,35.85,.625,11.975,.94,9040
50350 DATA 33,152
50400 DATA 603,618,633,647,661,2.94,44.7,33.49,.635,11.565,1.055,8160
50450 DATA 33,141
50500 DATA 559,373,787,600,613,2.92,41.6,33.3,.605,11.535,.96,7450
50550 DATA 36,135
50600 DATA 558,572,586,599,612,2.93,39.7,35.55,.6,11.95,.79,7800
50650 DATA 33,130
50700 DATA 512,525,538,550,562,2.88,38.3,33.09,.58,11.51,.855,6710
50750 DATA 30,132
50800 DATA 481,494,506,519,531,2.68,38.9,30.31,.615,10.545,1,5770
50850 DATA 33,118
50900 DATA 461,472,484,495,506,2.84,34.7,32.86,.55,11.48,.74,5900
50950 DATA 30,124
51000 DATA 451,463,475,486,498,2.66,36.5,30.17,.585,10.515,.93,5360
51050 DATA 30,116
51100 DATA 421,432,443,454,465,2.64,34.2,20.01,.565,10.495,.85,4930
51150 DATA 24,131
51200 DATA 409,420,431,443,454,3.4,38.5,24.48,.605,12.855,.96,4020
51250 DATA 30,108
51300 DATA 388,399,409,419,429,2.61,31.7,29.83,.545,10.475,.76,4470
51350 DATA 27,114
51400 DATA 383,394,404,415,425,2.58,33.5,27.29,.57,10.07,.93,4090
51450 DATA 24,117
51500 DATA 366,376,386,396,406,3.37,34.4,24.26,.55,12.8,.85,3540
51550 DATA 30,99
51600 DATA 354,364,373,382,392,2.57,29.1,29.65,.52,10.45,.67,3990
51650 DATA 27,102
51700 DATA 344,353,363,372,381,2.56,30.0,27.09,.515,10.015,.83,3620
51750 DATA 24,104
51800 DATA 325,334,343,352,362,3.25,30.6,24.06,.5,12.75,.75,3100
51850 DATA 27,94
51900 DATA 316,325,334,342,351,2.52,27.7,26.92,.49,9.99,.745,3270
51950 DATA 21,111
52000 DATA 314,324,333,343,353,3.28,32.7,21.51,.55,12.34,.875,2670
52050 DATA 18,119
52100 DATA 298,308,318,329,340,2.02,35.1,18.97,.655,11.265,1.06,2190
52150 DATA 24,94
52200 DATA 290,299,307,316,325,2.33,27.7,24.31,.515,9.065,.875,2700
52250 DATA 21,101
52300 DATA 288,296,305,314,323,3.27,29.8,21.36,.5,12.29,.8,2420
52350 DATA 27,84
52400 DATA 282,290,297,305,313,2.49,24.8,26.71,.46,9.96,.64,2850
52450 DATA 18,106
52500 DATA 265,274,283,292,302,3.0,31.1,18.72,.59,11.2,.94,1910
52550 DATA 24,84
52600 DATA 259,266,274,282,290,2.31,24.7,24.1,.47,9.02,.77,2370
52650 DATA 21,92
52700 DATA 256,264,272,281,290,2.17,27.2,21.62,.58,8.42,.93,2070
52750 DATA 18,97
52800 DATA 244,252,261,270,279,2.99,28.5,18.59,.535,11.145,.87,1750
52850 DATA 24,76
52900 DATA 234,241,248,255,262,2.29,22.4,23.92,.44,8.99,.68,2100
52950 DATA 16,100
```

```
53000 DATA 231,240,249,258,268,2.81,29.4,16.97,.585,10.425,.985,1490
53050 DATA 21,83
53100 DATA 229,236,244,252,260,2.15,24.3,21.43,.515,8.355,.835,1600
53150 DATA 18,86
53200 DATA 217,224,232,240,248,2.99,25.3,18.39,.48,11.09,.77,1530
53250 DATA 24,68
53300 DATA 209,215,221,228,234,2.26,20.1,23.73,.415,8.965,.585,1830
53350 DATA 16,89
53400 DATA 206,214,222,230,239,2.79,26.2,16.75,.525,10.365,.875,1300
53450 DATA 21,73
53500 DATA 203,210,217,224,231,2.13,21.5,21.24,.455,8.295,.74,1600
53550 DATA 18,76
53600 DATA 192,198,205,212,220,2.95,22.2,18.21,.425,11.035,.68,1330
53650 DATA 21,68
53700 DATA 189,196,202,208,215,2.12,20,21.13,.43,8.27,.685,1480
53750 DATA 24,62
53800 DATA 184,190,196,203,209,1.17,18.2,23.74,.43,7.04,.59,1550
53850 DATA 16,77
53900 DATA 179,186,193,200,208,2.77,22.6,16.52,.455,10.295,.76,1110
53950 DATA 18,71
54000 DATA 175,181,188,195,202,1.98,20.8,18.47,.495,7.635,.81,1170
54050 DATA 21,62
54100 DATA 173,179,185,191,197,2.1,18.3,20.99,.4,8.24,.615,1330
54150 DATA 24,55
54200 DATA 164,169,175,180,186,1.68,16.2,23.57,.395,7.005,.505,1250
54250 DATA 18,65
54300 DATA 161,167,173,180,187,1.97,19.1,18.35,.45,7.59,.75,1070
54350 DATA 16,67
54400 DATA 156,162,169,175,182,2.75,19.7,16.33,.394,10.235,.665,954
54450 DATA 21,57
54500 DATA 156,162,167,173,179,1.64,16.7,21.06,.405,6.555,.65,1170
54550 DATA 14,74
54600 DATA 153,160,167,174,182,2.71,21.8,14.17,.45,10.07,.785,723
54650 DATA 18,60
54700 DATA 144,155,160,166,173,1.96,17.6,18.24,.415,7.555,.695,984
54750 DATA 14,68
54800 DATA 141,147,154,161,168,2.71,20,14.04,.415,10.035,.72,723
54850 DATA 18,55
54900 DATA 137,142,147,153,159,1.95,16.2,18.11,.39,7.53,.63,890
54950 DATA 21,50
55000 DATA 136,141,146,151,157,1.6,14.7,20.83,.38,6.53,.535,984
55050 DATA 16,57
55100 DATA 131,136,142,148,154,1.86,16.8,16.43,.43,7.12,.715,758
55150 DATA 14,61
55200 DATA 127,132,138,145,151,2.7,17.9,13.89,.375,9.995,.645,640
55250 DATA 18,50
55300 DATA 125,129,134,140,145,1.94,14.7,17.99,.355,7.495,.57,800
55350 DATA 21,44
55400 DATA 120,124,129,133,138,1.57,13,20.66,.35,6.5,.45,843
55450 DATA 16,50
55500 DATA 115,120,125,130,136,1.84,14.7,16.25,.38,7.07,.63,659
55550 DATA 18,46
55600 DATA 114,118,123,128,133,1.54,13.5,18.06,.36,6.06,.605,712
55650 DATA 14,53
55700 DATA 110,115,120,126,132,2.15,15.6,13.92,.37,8.06,.66,541
55750 DATA 16,45
55800 DATA 104,108,113,118,123,1.83,13.3,16.13,.345,7.035,.565,586
```

```
55850 DATA 14,48
55900 DATA 99.6,104,109,115,120,2.13,14.1,13.79,.34,8.03,.595,485
55950 DATA 18,40
56000 DATA 99.4,103,108,112,116,1.52,11.8,17.9,.315,6.015,.525,612
56050 DATA 12,50
56100 DATA 94.2,99.2,105,110,116,2.17,14.7,12.19,.37,8.08,.64,394
56150 DATA 16,40
56200 DATA 92.9,96.9,101,105,110,1.82,11.8,16.01,.305,6.995,.505,518
56250 DATA 14,43
56300 DATA 89.3,93.6,98.1,103,108,2.12,12.6,13.66,.305,7.995,.53,428
56350 DATA 18,35
56400 DATA 86,89.6,93.4,97.3,101,1.49,10.3,17.7,.3,6,.425,510
56450 DATA 12,45
56500 DATA 85,89.6,94.4,99.3,104,2.15,13.2,12.06,.336,8.045,.575,350
56550 DATA 16,36
56600 DATA 82.8,86.5,90.4,94.4,98.4,1.79,10.6,15.86,.295,6.985,.43,448
56650 DATA 14,38
56700 DATA 80.4,84.3,88.5,92.7,97,1.77,11.2,14.1,.31,6.77,.515,385
56750 DATA 12,40
56800 DATA 76.3,80.5,84.9,89.3,93.9,2.14,11.8,11.94,.295,8.005,.515,310
56850 DATA 10,45
56900 DATA 75.5,80.3,85.3,90.4,95.7,2.18,13.3,10.1,.35,8.02,.62,248
56950 DATA 14,34
57000 DATA 72.1,75.6,79.3,83.1,87,1.76,10,13.98,.285,6.745,.455,340
57050 DATA 16,31
57100 DATA 71.9,74.5,77.9,81.4,84.9,1.39,9.12,15.88,.275,5.525,.44,375
57150 DATA 12,35
57200 DATA 68.6,72.3,76.1,80.1,84.1,1.74,10.3,12.5,.3,6.56,.52,285
57250 DATA 10,39
57300 DATA 65.6,69.8,74.2,78.6,83.2,2.16,11.5,9.92,.315,7.985,.53,209
57350 DATA 14,30
57400 DATA 63.6,66.8,70.1,73.5,76.9,1.74,8.85,13.84,.27,6.73,.385,291
57450 DATA 16,26
57500 DATA 59.7,62.5,65.4,68.3,71.3,1.36,7.68,15.69,.25,5.5,.345,301
57550 DATA 12,30
57600 DATA 58.8,62,65.3,68.7,72.1,1.73,8.79,12.34,.25,6.52,.44,238
57650 DATA 10,33
57700 DATA 55.5,59.1,62.8,66.7,70.6,2.14,9.71,9.73,.29,7.96,.435,170
57750 DATA 14,26
57800 DATA 55.2,58,60.9,63.9,66.9,1.28,7.69,13.91,.255,5.025..42,245
57850 DATA 8,35
57900 DATA 52.5,56.4,60.4,64.6,68.8,2.2,10.3,8.12,.31,8.02,.495,127
57950 DATA 10,30
58000 DATA 52.2,55.8,59.6,62.7,66.3,1.55.8.84,10.47,.3,5.81,.51,170
58050 DATA 12,26
58100 DATA 51.4,54.2,57.1,60.1,63.1,1.72,7.65,12.22,.23,6.44,.38,204
58150 DATA 8,31
58200 DATA 46.7,50.2,53.8,57.5,61.3,2.18,9.13,8,.285,7.995,.435,110
58250 DATA 14,22
58300 DATA 46.5,48.9,51.4,53.9,56.5,1.25,6.49,13.74,.23,5,.335,199
58350 DATA 10,26
58400 DATA 45.5,48.4,51.3,54.3,57.4,1.54,7.61,10.33,.26,5.77,.44,144
58450 DATA 8,28
58500 DATA 42.4,45.6,48.9,52.2,55.7,1.77,8.25,8.06,.285,6.535,.465,98
58550 DATA 12,22
58600 DATA 42.7,45.1,47.1,50.2,52.8,1.02,6.48,12.31,.26,4.03,.425,156
58650 DATA 10,22
```

```
58700 DATA 38.8,41.3,43.8,46.4,49,1.51,6.49,10.17,.24,5.75,.36,118
58750 DATA 8,24
58800 DATA 36.7,39.5,42.3,45.2,48.2,1.76,7.08,7.93,.245,6.495,.4,82.8
58850 DATA 12,19
58900 DATA 36.7,38.8,41,43.3,45.5,1.0,5.59,12.16,.235,4.005,.35,130
58950 DATA 10,19
59000 DATA 33.4,35.6,37.8,40.1,42.4,1.03,5.62,10.24,.25,4.02,.395,96.3
59050 DATA 8,21
59100 DATA 32.7,35.1,37.6,40.2,40.7,1.41,6.16,8.28,.25,5.27,.4,75.3
59150 DATA 12,16
59200 DATA 30.8,32.6,34.5,36.4,38.3,.96,4.71,11.99,.22,3.99,.265,103
59250 DATA 10,17
59300 DATA 29.5,31.5,33.5,35.5,37.6,1.01,4.99,10.11,.24,4.01,.33,81.9
59350 DATA 8,18
59400 DATA 28,30.1,32.2,34.4,36.6,1.39,5.26,8.14,.23,5.25,.33,61.9
59450 DATA 10,15
59500 DATA 26,27.7,29.5,31.3,33.2,.99,4.41,9.99,.23,4,.27,68.9
59550 DATA 8,15
59600 DATA 23.5,25.2,27.1,28.9,30.8,1.03 ,4.44,8.11,.245,4.015,.315,48
59650 DATA 10,12
59700 DATA 21,22.4,23.9,25.3,26.8,.96,3.54,9.87,.19,3.96,.21,53.8
59750 DATA 8,13
59800 DATA 20.3,21.8,23.4,25.1,26.7,1.01,3.84,7.99,.23,4,.255,39.6
59850 DATA 8,10
59900 DATA 15.9,17.1,18.4,19.6,20.9,0.99,2.96,7.89,.17,3.94,.205,30.8
59950 DATA .5,2,5.1,5.5,5.9
60000 DATA .625,2.5,8,8.6,9.2
60050 DATA .75,3,11.5,12.5,13.3
60100 DATA .875,3.5,15.6,16.8,18
60150 DATA W36X170
60200 DATA 713,731,748,765,50,36.17,.68,12.03,1.1,10500,11,3.04
60250 DATA W36X150
60300 DATA 628,644,659,673,44.2,35.85,.625,11.975,.94,9040,11,2.99
60350 DATA W36X135
60400 DATA 559,537,587,600,39.7,35.55,.6,11.95,.79,7800,11,2.93
60450 DATA W33X130
60500 DATA 512,525,538,550,38.3,33.09,.58,11.51,.855,6710,10,2.88
60550 DATA W33X118
60600 DATA 461,473,485,496,34.7,32.86,11.48,11.48,.74,5900,10,2.84
60650 DATA W30X108
60700 DATA 389,399,410.420,31.7,29.83,.545,10.475,.76,4470,9,2.61
60750 DATA W30X99
60800 DATA 354,364,374,383,29.1,29.65,.52,10.45,.67,3990,9,2.57
60850 DATA W27X102
60900 DATA 344,353,362,372,30,27.09,.515,10.015,.83,3620,9,2.56
60950 DATA W27X94
61000 DATA 316,325,334,342,27.2,26.92,.49,9.99,.745,3270,9,2.53
61050 DATA W27X84
61100 DATA 281,289,296,304,24.8,26.71,.46,9.96,.64,2850,9,2.49
61150 DATA W24X68
61200 DATA 207,214,220,227,20.1,23.73,.415,8.965,.585,1830,8,2.26
61250 DATA W24X55
61300 DATA 163,169,174,180,16.2,23.57,.355,7.005,.505,1350,6,1.68
61350 DATA W21X62
61400 DATA 173,179,185,191,18.3,20.99,.4,8.24,.615,1330,7,2.1
61450 DATA W21X57
61500 DATA 152,157,163,168,16.7,21.06,.405,6.555,.65,1170,5,1.64
```

```
61550 DATA W21X44
61600 DATA 120,124,129,133,13,20.66,.35,6.5,.45,843,5,1.57
61650 DATA W18X50
61700 DATA 126,129,134,140,14.7,17.99,.355,7.495,.57,800,6,1.94
61750 DATA W18X46
61800 DATA 112,116,121,126,13.5,18.06,.36,6.06,.605,712,5,1.54
61850 DATA W18X35
61900 DATA 86.2,89.8,93.6,97.4,10.3,17.7,.3,6,.425,510,5,1.49
61950 DATA W16X40
62000 DATA 92.8,96.8,101,105,11.3,16.01,.305,6.995,.505,518,6,1.82
62050 DATA 16X36
62100 DATA 82.8,86.5,90.3,94.3,10.6,15.86,.295,6.985,.43,448,6,1.79
62150 DATA W16X26
62200 DATA 59.5,62.4,65.2,68.2,7.68,15.69,.25,5.5,.345,301,4,1.36
62250 DATA W14X30
62300 DATA 63.4,66.6,69.9,73.3,8.85,13.84,.27,6.73,.385,291,6,1.74
62350 DATA W14X22
62400 DATA 46.4,48.9,51.3,53.9,6.49,13.74,.23,5,.335,199,4,1.25
62450 DATA W12X19
62500 DATA 36.8,38.4,41.1,43.4,5.57,12.16,.235,4.005,.35,130,3,1.0
```

10.4 COMPUTER SOLUTION OF THE DESIGN EXAMPLES

Computer Solution of Example No. 1

```
            COMPOSITE SECTION

      THE INPUT DATA
-----------------------------------------------------------------------
BEAM SPAN ------------------------------------------= 36 FT
BEAM SPACING----------------------------------------= 8 FT
UNIT WEIGHT OF THE CONCRETE-------------------------= 145 LB/FT^3
CONCRETE ULTIMATE STRENGTH -------------------------= 3000 PSI
STEEL YIELD STRENGTH -------------------------------= 36 KSI
LIVE LOAD ------------------------------------------= 128 LB/FT^2
**************************************************************
         ALLOWABLE STRESSES AND DEFLECTION
-----------------------------------------------------------------------
ALLOWABLE COMPRESSIVE STRESS IN CONCRETE SLAB-------= 1.35 KSI
ALLOWABLE TENSILE STRESS IN THE STEEL BEAM----------= 24 KSI
ALLOWABLE TENSILE SHEAR STRESSES IN THE STEEL BEAM= 14.4 KIPS
ALLOWABLE DEFLECTION DUE TO LIVE LOAD --------------= 1.2 IN
-----------------------------------------------------------------------
SOLID SLAB

SLAB THICKNESS ------- = 4 IN
DESIGN THE MOST ECONOMICAL SECTION
TRIAL NO.   1
STEEL BEAM   W 21 X 44

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =   1.64 %
THIS SECTION IS SAFE, FOR ECONOMY, THE PROGRAM WILL TRY THE NEXT SMALLER SECTION
TRIAL NO.   2
STEEL BEAM   W 18 X 40

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -18.18 %
THIS SECTION IS UNSAFE ,THE PREVIOUS SECTION IS THE BEST, THE PROGRAM WILL
 RE-DISPLAY THE PREVIOUS SECTION RESULT
M= 54
TRIAL NO.   3
STEEL BEAM   W 21 X 44

-----------------------------------------------------------------------
         MAXIMUM MOMENT AND SHEAR
-----------------------------------------------------------------------
MAXIMUM BENDING MOMENT -----------------------------=   235.68  KIPS FT
AT DISTANCE ----------------------------------------=    18.00 FT
MAXIMUM SHEARING FORCE -----------------------------=    26.19 KIPS
-----------------------------------------------------------------------
         SECTION PROPERTIES
-----------------------------------------------------------------------
EFFECTIVE SLAB WIDTH--------------------------------=    70.50 IN
DISTANCE FROM THE TOP OF CONCRETE SLAB TO CENTROID=      5.62 IN
TRANSFORMED MOMENT OF INERTIA-----------------------=  2281.62 IN^4
-----------------------------------------------------------------------
         ACTUAL STRESSES AND DEFLECTION
-----------------------------------------------------------------------
STRESS  AT THE TOP FIBER OF THE CONCRETE SLAB------=  0.54 KSI
STRESS AT THE TOP FIBER OF THE STEEL BEAM ---------= 10.26 KSI
STRESS AT THE BOTTOM FIBER OF THE STEEL BEAM-------= 23.61 KSI
SHEAR STRESS IN THE WEB OF THE STEEL BEAM ---------=  3.62 KSI
DEFLECTION DUE TO DEAD LOAD------------------------=  0.67 IN
DEFLECTION DUE TO LIVE LOAD -----------------------=  0.59 IN
```

```
---------------------------------------------------------------------------
          REMARKS

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =   1.64 %
THIS SECTION IS SAFE AND THE MOST ECONOMICAL
M= 54
BEAM SHOULD BE LATERALLY SUPPORTED EVERY     16.84 FT DURING CONSTRUCTION
---------------------------------------------------------------------------

---------------------------------------------------------------------------
          SHEAR CONNECTORS
---------------------------------------------------------------------------
TOTAL NO. OF SHEAR CONNECTORS--------------------= 42
NO. OF  SHEAR CONNECTORS TO BE USED EACH SIDE----= 21
SHEAR RESISTANCE OF EACH SHEAR CONNECTOR---------= 11.5 KIPS
*******************************************************************
```

Computer Solution of Example No. 2

```
              COMPOSITE SECTION

         THE INPUT DATA

------------------------------------------------------------------------
BEAM SPAN ---------------------------------------------= 36 FT
BEAM SPACING-------------------------------------------= 8 FT
UNIT WEIGHT OF THE CONCRETE----------------------------= 145 LB/FT^3
CONCRETE ULTIMATE STRENGTH ----------------------------= 3000 PSI
STEEL YIELD STRENGTH ----------------------------------= 36 KSI
LIVE LOAD ---------------------------------------------= 128 LB/FT^2
****************************************************************
         ALLOWABLE STRESSES AND DEFLECTION

------------------------------------------------------------------------
ALLOWABLE COMPRESSIVE STRESS IN CONCRETE SLAB--------= 1.35 KSI
ALLOWABLE TENSILE STRESS IN THE STEEL BEAM----------= 24 KSI
ALLOWABLE TENSILE SHEAR STRESSES IN THE STEEL BEAM= 14.4 KIPS
ALLOWABLE DEFLECTION DUE TO LIVE LOAD --------------= 1.2 IN

------------------------------------------------------------------------
SLAB ON FORMED STEEL DECK PERPENDICULAR TO THE BEAM

THICKNESS OF THE CONCRETE SLAB ABOVE THE STEEL DECK =  2 IN
DEPTH OF THE RIBS ----------------------------------=  2 IN
DISTANCE FROM CENTER TO CENTER OF THE RIBS ---------=  6 IN
TOP CLEAR WIDTH OF THE RIBS ------------------------=  3.5 IN
BOTTOM CLEAR WIDTH OF THE RIBS----------------------=  2.5 IN
DESIGN THE MOST ECONOMICAL SECTION
TRIAL NO.   1
STEEL BEAM   W 18 X 46

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =   3.36 %
THIS SECTION IS SAFE, FOR ECONOMY, THE PROGRAM WILL TRY THE NEXT SMALLER SECTION
TRIAL NO.   2
STEEL BEAM   W 16 X 45

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =  -5.02 %
THIS SECTION IS UNSAFE ,THE PREVIOUS SECTION IS THE BEST, THE PROGRAM WILL
 RE-DISPLAY THE PREVIOUS SECTION RESULT
M= 56
TRIAL NO.   3
STEEL BEAM   W 18 X 46

------------------------------------------------------------------------
         MAXIMUM MOMENT AND SHEAR

------------------------------------------------------------------------
MAXIMUM BENDING MOMENT ----------------------------=   220.30  KIPS FT
AT DISTANCE ---------------------------------------=   18.00 FT
MAXIMUM SHEARING FORCE ----------------------------=   24.48 KIPS

------------------------------------------------------------------------
         SECTION PROPERTIES

------------------------------------------------------------------------
EFFECTIVE SLAB WIDTH-------------------------------=   70.06 IN
DISTANCE FROM THE TOP OF CONCRETE SLAB TO CENTROID=    6.59 IN
TRANSFORMED MOMENT OF INERTIA---------------------=  1763.58 IN^4
------------------------------------------------------------------------
```

```
ACTUAL STRESSES AND DEFLECTION

----------------------------------------------------------------------------
STRESS AT THE TOP FIBER OF THE CONCRETE SLAB------=  0.83 KSI
STRESS AT THE TOP FIBER OF THE STEEL BEAM --------=  8.28 KSI
STRESS AT THE BOTTOM FIBER OF THE STEEL BEAM------= 23.19 KSI
SHEAR STRESS IN THE WEB OF THE STEEL BEAM --------=  3.76 KSI
DEFLECTION DUE TO DEAD LOAD-----------------------=  0.62 IN
DEFLECTION DUE TO LIVE LOAD ----------------------=  0.76 IN
----------------------------------------------------------------------------
          REMARKS

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =   3.36 %
THIS SECTION IS SAFE AND THE MOST ECONOMICAL
BEAM SHOULD BE LATERALLY SUPPORTED EVERY     18.39 FT DURING CONSTRUCTION
----------------------------------------------------------------------------
----------------------------------------------------------------------------
          SHEAR CONNECTORS
----------------------------------------------------------------------------
TOTAL NO. OF SHEAR CONNECTORS--------------------= 40
NO. OF  SHEAR CONNECTORS TO BE USED EACH SIDE----= 20
SHEAR RESISTANCE OF EACH SHEAR CONNECTOR---------= 11.5 KIPS
STUD CONNECTORS LENGTH  ---------------------= 3.5 IN
*********************************************************************
```

Note

Length of the stud connectors increased from 3 in. to 3.5 in. to comply with metal deck requirement (1.5 in. above the top of the metal deck).

Computer Solution of Example No. 3

COMPOSITE SECTION

THE INPUT DATA

```
---------------------------------------------------------------------------
BEAM SPAN ---------------------------------------------= 36 FT
BEAM SPACING------------------------------------------= 8 FT
UNIT WEIGHT OF THE CONCRETE---------------------------= 145 LB/FT^3
CONCRETE ULTIMATE STRENGTH ---------------------------= 3000 PSI
STEEL YIELD STRENGTH ---------------------------------= 36 KSI
LIVE LOAD --------------------------------------------= 128 LB/FT^2
*******************************************************************
        ALLOWABLE STRESSES AND DEFLECTION
---------------------------------------------------------------------------
ALLOWABLE COMPRESSIVE STRESS IN CONCRETE SLAB--------= 1.35 KSI
ALLOWABLE TENSILE STRESS IN THE STEEL BEAM-----------= 24 KSI
ALLOWABLE TENSILE SHEAR STRESSES IN THE STEEL BEAM= 14.4 KIPS
ALLOWABLE DEFLECTION DUE TO LIVE LOAD ---------------= 1.2 IN
---------------------------------------------------------------------------
SLAB ON FORMED STEEL DECK PARALLEL TO THE BEAM

THICKNESS OF THE CONCRETE SLAB ABOVE THE STEEL DECK =  2 IN
DEPTH OF THE RIBS ----------------------------------=  2 IN
DISTANCE FROM CENTER TO CENTER OF THE RIBS ---------=  6 IN
TOP CLEAR WIDTH OF THE RIBS ------------------------=  3.5 IN
BOTTOM CLEAR WIDTH OF THE RIBS----------------------=  2.5 IN
DESIGN THE MOST ECONOMICAL SECTION
TRIAL NO.   1
STEEL BEAM   W 18 X 46

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =   3.17 %
THIS SECTION IS SAFE, FOR ECONOMY, THE PROGRAM WILL TRY THE NEXT SMALLER SECTION
TRIAL NO.   2
STEEL BEAM   W 16 X 45

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =  -5.49 %
THIS SECTION IS UNSAFE ,THE PREVIOUS SECTION IS THE BEST, THE PROGRAM WILL
 RE-DISPLAY THE PREVIOUS SECTION RESULT
M= 56
TRIAL NO.   3
STEEL BEAM   W 18 X 46

---------------------------------------------------------------------------
        MAXIMUM MOMENT AND SHEAR
---------------------------------------------------------------------------
MAXIMUM BENDING MOMENT ------------------------------=   220.30  KIPS FT
AT DISTANCE -----------------------------------------=    18.00 FT
MAXIMUM SHEARING FORCE ------------------------------=    24.48 KIPS
---------------------------------------------------------------------------
        SECTION PROPERTIES
---------------------------------------------------------------------------
EFFECTIVE SLAB WIDTH--------------------------------=    70.06 IN
DISTANCE FROM THE TOP OF CONCRETE SLAB TO CENTROID=     5.82 IN
TRANSFORMED MOMENT OF INERTIA-----------------------=  1847.62 IN^4
---------------------------------------------------------------------------
```

```
-----------------------------------------------------------------------------
         ACTUAL STRESSES AND DEFLECTION
-----------------------------------------------------------------------------
STRESS  AT THE TOP FIBER OF THE CONCRETE SLAB------=   0.70 KSI
STRESS AT THE TOP FIBER OF THE STEEL BEAM --------=   8.28 KSI
STRESS AT THE BOTTOM FIBER OF THE STEEL BEAM------=  23.24 KSI
SHEAR STRESS IN THE WEB OF THE STEEL BEAM ---------=   3.76 KSI
DEFLECTION DUE TO DEAD LOAD-----------------------=   0.62 IN
DEFLECTION DUE TO LIVE LOAD ----------------------=   0.73 IN
-----------------------------------------------------------------------------
         REMARKS

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =    3.17 %
THIS SECTION IS SAFE AND THE MOST ECONOMICAL
BEAM SHOULD BE LATERALLY SUPPORTED EVERY      18.39 FT DURING CONSTRUCTION
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
         SHEAR CONNECTORS
-----------------------------------------------------------------------------
TOTAL NO. OF SHEAR CONNECTORS---------------------= 76
NO. OF  SHEAR CONNECTORS TO BE USED EACH SIDE-----= 38
SHEAR RESISTANCE OF EACH SHEAR CONNECTOR----------= 11.5 KIPS
STUD CONNECTORS LENGTH  -----------------------= 3.5 IN
*****************************************************************************
```

Note

Length of the stud connectors increased from 3 in. to 3.5 in. to comply with metal deck requirement (1.5 in. above the top of the metal deck).

Computer Solution of Example No. 4

```
                COMPOSITE SECTION

        THE INPUT DATA
-----------------------------------------------------------------------
BEAM SPAN ---------------------------------------------= 40 FT
BEAM SPACING-------------------------------------------= 35 FT
UNIT WEIGHT OF THE CONCRETE----------------------------= 150 LB/FT^3
CONCRETE ULTIMATE STRENGTH ----------------------------= 3000 PSI
STEEL YIELD STRENGTH ----------------------------------= 36 KSI
LIVE LOAD ---------------------------------------------= 0 LB/FT^2
CONCENTRATED LOADS

NO. OF CONCENTRATED LOADS ---------------= 3
LOAD NO.  1
DEAD LOAD PORTION -----------------------= 21.8 KIPS
LIVE LOAD PORTION -----------------------= 45.5 KIPS
AT DISTANCE FROM THE LEFT SUPPORT -------= 10  FT
LOAD NO.  2
DEAD LOAD PORTION -----------------------= 21.8 KIPS
LIVE LOAD PORTION -----------------------= 45.5 KIPS
AT DISTANCE FROM THE LEFT SUPPORT -------= 20  FT
LOAD NO.  3
DEAD LOAD PORTION -----------------------= 21.8 KIPS
LIVE LOAD PORTION -----------------------= 45.5 KIPS
AT DISTANCE FROM THE LEFT SUPPORT -------= 30  FT
*****************************************************************
        ALLOWABLE STRESSES AND DEFLECTION
-----------------------------------------------------------------------
ALLOWABLE COMPRESSIVE STRESS IN CONCRETE SLAB--------= 1.35 KSI
ALLOWABLE TENSILE STRESS IN THE STEEL BEAM----------= 24 KSI
ALLOWABLE TENSILE SHEAR STRESSES IN THE STEEL BEAM= 14.4 KIPS
ALLOWABLE DEFLECTION DUE TO LIVE LOAD --------------= 1.333333 IN
-----------------------------------------------------------------------
SOLID SLAB

SLAB THICKNESS ------- = 4.5 IN
DESIGN FOR DEPTH RESTRICTION

TRIAL NO. 1

STEEL BEAM   W27X102
CONCRETE STRESS IS UNSAFE, INCREASE THICKNESS OR STRENGTH OF THE CONCRETE SLAB
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -93.29 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= .25 IN
TRIAL NO. 2

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = .25
TOTAL DEPTH= 31.84
```

```
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -66.17 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= .375 IN
TRIAL NO. 3

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = .375
TOTAL DEPTH= 31.965
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -55.33 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= .5 IN
TRIAL NO. 4

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = .5
TOTAL DEPTH= 32.09
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -45.86 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= .625 IN
TRIAL NO. 5

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = .625
TOTAL DEPTH= 32.215
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -37.51 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= .75 IN
TRIAL NO. 6

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = .75
TOTAL DEPTH= 32.34
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -30.10 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= .875 IN
TRIAL NO. 7

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = .875
TOTAL DEPTH= 32.465
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -23.47 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= 1 IN
TRIAL NO. 8

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = 1
TOTAL DEPTH= 32.59
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -17.51 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= 1.125 IN
TRIAL NO. 9

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = 1.125
TOTAL DEPTH= 32.715

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES = -12.13 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= 1.25 IN
```

```
TRIAL NO. 10

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = 1.25
TOTAL DEPTH= 32.84
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =  -7.24 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= 1.375 IN
TRIAL NO. 11

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = 1.375
TOTAL DEPTH= 32.965
DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =  -2.78 %
THIS SECTION IS UNSAFE THE PROGRAM WILL USE COVER PLATE WITH THICKNESS
= 1.5 IN
TRIAL NO. 12

STEEL BEAM   W27X102
THICKNESS OF THE COVER PLATE = 1.5
TOTAL DEPTH= 33.09
-----------------------------------------------------------------------
          MAXIMUM MOMENT AND SHEAR
-----------------------------------------------------------------------
MAXIMUM BENDING MOMENT ---------------------------=  1375.56  KIPS FT
AT DISTANCE -------------------------------------=    20.00 FT
MAXIMUM SHEARING FORCE ---------------------------=   103.91 KIPS
-----------------------------------------------------------------------
          SECTION PROPERTIES
-----------------------------------------------------------------------
EFFECTIVE SLAB WIDTH-----------------------------=    82.02 IN
DISTANCE FROM THE TOP OF CONCRETE SLAB TO CENTROID=    12.66 IN
TRANSFORMED MOMENT OF INERTIA--------------------= 14234.16 IN^4
-----------------------------------------------------------------------
          ACTUAL STRESSES AND DEFLECTION
-----------------------------------------------------------------------
STRESS  AT THE TOP FIBER OF THE CONCRETE SLAB------=  1.08 KSI
STRESS AT THE TOP FIBER OF THE STEEL BEAM ---------= 18.18 KSI
STRESS AT THE BOTTOM FIBER OF THE STEEL BEAM-------= 23.69 KSI
SHEAR STRESS IN THE WEB OF THE STEEL BEAM ---------=  7.45 KSI
DEFLECTION DUE TO LIVE LOAD ----------------------=  0.60 IN
-----------------------------------------------------------------------
          REMARKS

DIFFERENCE BETWEEN THE ALLOWABLE AND ACTUAL STRESSES =    1.30 %
SECTION IS SAFE AND ECONOMICAL
COVER PLATE

LEFT THEORETICAL CUT OFF POINT ------------------= 6.75 FTFROM THE LEFT SUPPORT
RIGHT THEORETICAL CUT OFF POINT -----------------= 6.75 FTFROM THE RIGHT SUPPOR
T
WIDTH OF THE COVER PLATE ------------------= 9 IN
NOTE : DEVELOPING LENGTH MUST BE ADDED TO BOTH SIDES
BEAM SHOULD BE LATERALLY SUPPORTED EVERY     17.68 FT DURING CONSTRUCTION
-----------------------------------------------------------------------
```

SHEAR CONNECTORS

```
NO. OF STUDS FROM POINT  0 FT  TO POINT 10 FT  = 21
NO. OF STUDS FROM POINT  10 FT  TO POINT 20 FT  = 21
NO. OF STUDS FROM POINT  20 FT  TO POINT 30 FT  = 21
NO. OF STUDS FROM POINT  30 FT  TO POINT 40 FT  = 21
SHEAR RESISTANCE OF EACH SHEAR CONNECTOR---------= 11.5 KIPS
****************************************************************
```

A MICROCOMPUTER PROGRAM FOR THE DESIGN OF COMPOSITE BEAMS

by

NABIL M. TAHA

B. S., Cairo University, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

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Manhattan, Kansas

1985

ABSTRACT

A micro-computer program has been developed to design unshored, simply supported beams according to the AISC Specification. The program has been designed to allow the use of concrete strengths from 3000 to 8000 psi, steel yield strengths of 36 or 50 ksi, uniformly distributed or concentrated loads or a combination of the two, and solid slabs or slabs on formed steel deck. The program may design the most economical section, review a specific standard section, review a specified built-up section or design for a depth restriction using a cover plate if necessary. Headed studs are used for shear connectors so full composite action can be attained. Simplified and detailed flow diagrams are included, and four examples are presented to illustrate the use of the program.