A girder/concrete combination including tie means for uniting the girder and concrete slab wherein longitudinal stress forces are compensated for by slots, notches, projections, undulations or the like formed integrally along the length of the girder and transverse forces are compensated for by the tie means which may take the form of webs of continuous lengths of rigid material placed on each side of the girder and mechanically spaced therefrom.

The present invention relates to a girder/concrete structural combination and more particularly to the union between hot or cold rolled girders and concrete slabs. A union between a cold rolled girder and a concrete slab is usually effected by welding, riveting or bolting, or by simply inserting bars in holes provided in the girders and subsequently pouring concrete around this girder arrangement. Prior art techniques of affixing the tie bars to the girders have the disadvantage of being difficult to apply, expensive and unreliable.

In practice, welding or fixing of the bars to the upper flange of the girders in the workshop makes the subsequent handling of the girders and their transport, unloading and assembly difficult and liable to cause injury if insufficient care is taken. Fixing or welding of the bars after the girders have been put in place is costly. The men involved in the work must be specialists and have to execute the work with their bodies in badly balanced positions or with the aid of movable scaffolding, the cost of erection of which is out of proportion to the work to be done. If the bar is simply inserted in a hole in the web, the diameter of the hole has to be larger than that of the bar; contact is only assured with a degree of uncertainty and the pressure on the interstitial mortar exceeds the permissible limit. The control offices (Veritas, Securitas, etc.) then demand supplementary welding at the point of contact, which involves extra expense.

Summary of the invention

The present invention relates to a girder/concrete combination including a novel tie means for uniting a girder and concrete slab. With the arrangement of the present invention, longitudinal stress forces upon the girder/concrete combination are compensated for by means formed integrally with the girder such as slots, notches, projections or undulations formed along the length of the girder member. Transverse forces on the girder/concrete combination are compensated for by tie means which may take the form of webs of continuous and convenient lengths of rigid material placed on each side of the girder and mechanically spaced therefrom.

Among the objects of the present invention, are the provision of a girder/concrete combination having separate means to provide effective resistance to both longitudinal and transverse stresses, the provision of a girder/concrete combination wherein longitudinal forces are compensated by means integrally formed on the girder and transverse forces are compensated by tie means formed in the concrete slab mechanically spaced from the girder.

Other objects in further scope of applicability of the present invention will become apparent from the detailed description given below in conjunction with the accompanying drawings.

Brief description of the drawings

The invention is further described with reference to the accompanying drawings, in which:

FIG. 1 is a cross-section of a girder combined with a concrete slab according to the invention;
FIG. 2 is a cross-section on a larger scale of a hot-laminated girder having projections on each side of the web;
FIG. 3 is a side view of the girder illustrated in FIG. 2;
FIG. 4 is a side view of a hot-laminated girder having on each side of the web a row of projections which is staggered relationship to the row of projections on the other side;
FIG. 5 is a side view of a hot-laminated girder on the web of which there are provided bosses or half-formed slots which were produced during rolling;
FIG. 6 is a longitudinal section through the girder shown in FIG. 5 in the portion which has the half-formed slots;
FIG. 7 is a side view of a hot-laminated girder whose web bears crossed striations;
FIG. 8 is a cross-section of a hot-laminated girder whose lower flange has twice the thickness of the upper flange;
FIG. 9 is a perspective view of a hot-laminated girder whose upper flange has undulations at each edge, said undulations diminishing in amplitude towards the centre portion of the flange, which remains plane;
FIG. 10 is a cross-section of a cold-laminated girder produced by welding two symmetrical elements back to back, the web being provided with half-formed slots produced during cold rolling;
FIG. 11 is a cross-section of a cold-laminated girder with unequal flanges;
FIG. 12 is a cross-section of a cold-laminated girder whose upper flanges are bent in the same direction as the lower flanges;
FIG. 13 is a cross-section of a cold-laminated girder such as is illustrated in FIG. 12, illustrating its use for bearing considerable overloads, added carrying metal being provided in the form of two round iron bars placed above the lower flange of the girder;
FIG. 14 is a cross-section of a girder/concrete combination having tie means consisting of two webs of metal lattice-work placed one on each side of the girder;
FIG. 15 is a cross-section of a girder/concrete combination having tie-means consisting of a single web of lattice-work in the shape of an inverted U and placed over the girder;
FIG. 16 is a cross-section of a girder/concrete combination having tie-means consisting of bars placed on each side of the girder and bent so as to form a continuous meandering pattern or a Greek key-pattern as illustrated in FIG. 17;
FIG. 18 is a cross-section of a girder/concrete combination with means provided for suspension of the ceiling;
FIG. 19 is a view from below of the means for suspension of the ceiling.

Description of the preferred embodiments

The reinforced girder/concrete structural member of the present invention includes a means formed integral with the girder for providing effective resistance to longitudinal forces transmitted to the member and a tie means to unite the girder and concrete sections of the member to form an effective resistance against transverse forces. The reinforced girder/concrete structural member is adapted for use in floors of buildings which support loads ranging from 175 to 300 kilograms per square meter or from 300 to 100 kilograms per square meter. The girder
used in the structural member may be either hot or cold rolled and is provided with slots or notches, formed by punching methods, or with detented projections formed in the web of the girder by means of rolling cylinders carrying suitable projections for the purpose. These protuberances on the girder are preferably disposed of on each side of the web or the girder at a desired height. Additionally the upper flange of the girder may be provided with undulations along its edges, which undulations diminished toward the center line of the girder to provide an anti-sagging effect in the girder in the pre-stress of the lower flange.

In another embodiment, the girders may be formed with two half-sections joined by welding the webs of which include protuberances that are directly obtained during lamination. In a further embodiment, the structural member utilizes girders whose lower flange is twice the thickness of the upper flange. A still further embodiment includes a girder having an upper flange that is notched on each side in the form of simple recesses or with embossed profiles.

The tie means may be of the conventional individual type consisting of round or flat bars, but it is preferred to use tie means consisting of bands of welded lattice-work or bands of expanded steel placed on each side of the girder or a single band bent into the shape of an inverted U and placed over the girder with the arms of the U on each side thereof.

In a preferred embodiment, the tie means consists of bars bent in a continuous meandering pattern or a continuous Greek key-pattern of suitable height and pitch which are placed on each side of the girder.

When a straight beam is supported at two points, it is economical to use a girder whose lower flange is wider than its upper flange and to place a prop under the girder until the concrete has set, the prop being adjustable so as to introduce a degree of re-stress into the girder.

However, the use of a prop may be avoided if a girder of sufficient resistance is used which has been provided with a counter-sag or has been pre-stressed so that the sag under the weight under the concrete is zero. Another way of dispensing with the prop is to effect concreting in two stages, the first concreting providing, with the girder, support for the final concrete. Finally on account of the simplification of the work on the site that it provides, a cold-laminated girder may be considered for use which is high but less thick and serves as self-supporting framing during concreting and additional anchoring metal being provided in the form of two iron round bars placed on each side of the web above the lower flange of the girder.

In the accompanying drawings, 1 is the girder, which may be of standard or specially designed type, 2 is the slab of concrete supported by both the upper and the lower flange of the girder by way of a downward projection which encloses the girder except for the underside of the lower flange, full flame protection being provided by the provision of a non-inflammable ceiling. The downward projections are shaped so as to provide a sufficient covering of concrete for the tie means 3 embedded therein. 4 designates the inter-girder reinforcement of the slab 2 against bending stresses and is preferably composed of welded lattice-work. 5 designates the projections provided on each side of the web of the girder during hot rolling, the projections being formed, for example, by cutting three sides of the opening in the press and subsequently bending back the metal by stamping at right angles to the web. The number and size of the projections are calculated on the basis that the adherence between the concrete and the girder is impaired by vibrations for example and that these projections fill the role of an anchorage preventing the separation of the concrete from the steel. Such projections can, when provided during rolling, conveniently take the form of bosses 6 or half-formed slots 7. Finally, the web of the hot-laminated girder may be provided with striations or grooves 8 on each side of means of suitable engraving on the rolling cylinders. It can in some cases be useful to lower the centre of gravity of the girder by providing it with unequal flanges, the lower flange, which is more remote from the centre of gravity of the girder/concrete combination, being more massive.

A particularly convenient form of girder for opposing the longitudinal shearing forces comprises a girder whose upper flange, which is compressed under the weight of the concrete, is provided with slight undulations at its edges. The raised portions 10 that produced movement in the longitudinal direction between the girder and the concrete. In addition, the undulation 10 of the upper flange, which diminishes towards the center line of the flange, imparts a tension to the central plane portion 9 of the upper flange which is deliberately kept below the limit of elasticity, while the tension in the undulated zones exceeds this limit. This stretching of the material of the upper flange leads to compression in the lower flange and thus produces a counter-sag. Tests have made it possible to establish the pre-stresses, both tensile and compressive, as a function of the sag. The undulations may be produced by rolling or, wave by wave, in a press. This method of pre-stressing girders to be used, as in the present case, for resisting bending forces may find more general applications than the making of girder/concrete combination.

The cold-laminated girder is made by joining two symmetrical halves back to back by means of two continuous or discontinuous lines of welding 11 and 12. It may be convenient to bend the marginal regions of the upper compressed flange upwardly instead of downwardly, as is usual, so as to provide vertical strips 13 for the attachment of distance bars 14 to avoid the risk of twisting, which must be taken into account with cold-laminated girders which are very thin and are unpropped, when the girders are required to bear a considerable load. For the absorption of substantial overload extra metal is provided in the form of round bars 15. 16 designates two webs of welded lattice-work or expanded metal enclosing the girder and forming the tie means, 17 designates a wider band which is bent to form an inverted U and then placed over the girder. The bars forming the tie means may take a meandering form, as designated by 18 in FIG. 17, or the form of a Greek key-pattern, as designated by 19. These forms have the advantage that the tie means can interface with the reinforcement means 4 of the compression slab so that no movement can take place between the slab and the girder without the introduction of a secondary force.

The points of suspension for the ceiling may be simply and economically provided by suspending two angle pieces 20, or two U-shaped pieces or two pieces with asymmetrical flanges, from the exposed edges of the lower flange of the girder and interconnecting the pieces 20 by a bolt 21. Two further bolts 22 are used to space the pieces 20 and allow for the fixing of a gusset 23 for the suspension of the bolt used to support the ceiling element. This arrangement is convenient as the point of suspension of the ceiling may pass along the axis of the girder, including at points where the upper surface of the lower flange of the girder is covered.

1 claim:
1. In a girder for use in reinforced concrete construction and having an L-shaped cross-section to define an upper flange, a lower flange and a web and a central portion connecting said flanges at the longitudinal centers thereof, the improvement comprising: a series of undulations in said upper flange, said undulations being of maximum amplitude at the outer edges of said flanges and diminishing to zero amplitude at the central portion of said upper flange near said web, said undulations being formed by stretching the material of said upper flange beyond the elastic limit thereof so that the central zone of said upper flange is under a tensile stress within said elastic limits,
said tensile stress being transmitted through said web to stress said lower flange in compression thereby to prestress said girder against sag under loading.

2. A load supporting reinforced concrete floor structure comprising in combination: a molded span of concrete and reinforcement means embedded in said concrete, said reinforcing means comprising a girder extending the length of said span, said girder having an I-shaped cross-section to define an upper flange, a lower flange and an integral web interconnecting said flanges at the longitudinal centers thereof, said upper flange having formed therein a series of undulations of maximum amplitude at the outer edges of said flange and diminishing to zero amplitude at the central portion of said upper flange near said web, said undulations being formed by stretching the material of said upper flange beyond the elastic limit thereof so that the central zone of said upper flange is tensile stress within said elastic limits, said tensile stress being transmitted through said web to stress lower flange in compression, thereby to pre-stress said girder against sag under loading, said undulations operating further to anchor said upper flange against slippage in said molded concrete span, and tie means for absorbing overloads, said tie means comprising a continuous lattice-work of inverted U-shaped cross-section to define a transverse portion between a pair of depending side portions, said tie means being disposed over said girder and spaced therefrom at all points, and said side portions extending over the major portion of the depth of said girder.

References Cited

UNITED STATES PATENTS

610,139 8/1898 Jenkins -------------- 52—339 X
735,759 8/1903 Guest -------------- 52—734
749,987 1/1904 Franke -------------- 52—734
1,422,694 7/1922 Gogkel -------------- 52—735
1,708,418 4/1929 Jones -------------- 52—339
2,455,998 2/1948 Cueni -------------- 52—223
3,303,627 2/1967 Mora -------------- 52—723
733,187 7/1903 Grant -------------- 52—699 XR
2,410,922 11/1946 Balduf -------------- 52—347 XR
2,773,512 12/1956 Burk -------------- 264—35 XR

FOREIGN PATENTS

910,506 4/1946 France.

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U.S. Cl. X.R.

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