A joist-and-deck floor construction system uses open-web steel joists (OWSJ) having continuous top-chord cap plates to facilitate continuous placement of corrugated steel deck over the OWSJs and to allow shear connectors to be field-applied to the cap plates, through the lower flutes of the deck, to achieve composite structural action between the OWSJ and a concrete floor slab poured over the deck. A composite steel stud wall construction system has a bottom track perforated to receive reinforcing dowels projecting from a concrete support element, such that infill concrete may be placed to a desired height within the stud assembly to give the lower ends of the studs a significant degree of structural fixity. The stud wall can also be constructed on top of steel floor deck, prior to placement of floor concrete.
COMPOSITE FLOOR AND COMPOSITE STEEL STUD WALL CONSTRUCTION SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS


FIELD OF THE INVENTION

[0002] The present invention relates to floor and wall construction methods and systems using steel floor and wall framing members, and relates in particular to composite floor construction using steel joists supporting concrete-topped decking in conjunction with composite steel beams and wall construction systems using light-gauge steel stud framing members.

BACKGROUND OF THE INVENTION

Load-Bearing Wall Construction

[0003] In conventional construction of multi-storey structures comprising load-bearing walls, platform framing technique is used. As the name suggests, platform framing relies on the floor assembly to provide a platform for subsequent framing construction. The lower floor supporting elements, usually the load-bearing walls, are constructed, then the floor elements installed, directly bearing on the supporting elements below. The follow-up bearing walls are then constructed, followed by the next upper floor assembly. The process repeats itself until the roof elements are installed. All modern floor systems involve the use of concrete as an integral part of the floor assembly. The fact that subsequent floor construction follows the completion of the floor assembly below means a significant delay in waiting for the concrete to cure.

[0004] Attempts have been made to eliminate or minimize delays in platform construction. U.S. Pat. No. 4,486,993 (Graham et al.), U.S. Pat. No. 5,881,516 (Luedtke), and U.S. Pat. No. 5,782,047 as well as U.S. Pat. No. 6,298,617 (de Quesada), deal in varying degrees with methods of constructing bearing walls whereby the upper wall assembly can proceed before completion of the floor elements.

[0005] U.S. Pat. No. 4,486,993 (Graham et al.) employs hot rolled angles attached to a foam-cored lattice bearing wall for floor assembly support.

[0006] U.S. Pat. No. 5,782,047 (de Quesada) employs hot-rolled ledge angles attached to light-gauge C-shaped channel steel stud bearing walls for bearing support of the concrete-topped floor assemblies. Floor concrete may terminate at the sides of the load-bearing walls, or may be carried continuously between the upper and lower wall assemblies. In the latter case (with concrete running between upper and lower assemblies), the upper wall assembly is supported on equally spaced screw-jack assemblies allowing the upper wall assembly to proceed before the floor concrete.

[0007] In U.S. Pat. No. 6,298,417 (de Quesada), a hat section is placed on top of the lower wall panel, with legs projecting horizontally out to support floor joists (instead of hot-rolled ledge angles as in U.S. Pat. No. 5,782,047). In place of screw-jack assemblies, discrete connectors are used. These connectors are shop-welded to the bottom of the upper wall panel, and site welded to the top of the bottom panel.

[0008] U.S. Pat. No. 5,881,516 (Luedtke) deals with load-bearing wall systems wherein the axial load does not pass through the floor assembly. Wall systems include both wood and conventional steel stud bearing walls. Floor assemblies include wood joists, light-gauge steel C-joists, and low-profile composite steel decks. The floor assemblies are supported, outside of the plane of the bearing wall, by various metal devices.

[0009] Underlying all of the above-referenced U.S. patent documents is the premise of carrying the floor load outside of the plane of the bearing wall. This very premise, however, creates eccentricity in the loading, and significantly reduces the load-carrying capacity of the bearing wall. Both Luedtke (U.S. Pat. No. 5,881,516) and de Quesada (U.S. Pat. No. 5,782,047 and U.S. Pat. No. 6,298,417) deal with shallow floor assemblies, i.e. low-profile floor decks (less than 76 mm in depth) and C-joists. The more common steel floor systems, using open-web steel joists (OWSJ) and medium/ deep profile composite floor decks (greater than 76 mm in depth) are not discussed. With significantly increased spans associated with these more common systems, the eccentric bearing details become costly and complicated.

[0010] While continuity of the concrete in the floor assembly is maintained within the plane of the load bearing walls to maintain continuous inter-floor fire and acoustic separation across the bearing walls, neither Luedtke (U.S. Pat. No. 5,881,516) nor Graham (U.S. Pat. No. 5,782,047 and U.S. Pat. No. 6,298,417) makes structural use of the concrete. Hence, secondary structural elements are still required over window or door openings in the wall panels.

[0011] For the foregoing reasons, there is a need for metal stud load-bearing wall systems that:

[0012] Permit upper floor-wall assemblies to proceed prior to installing floor concrete;

[0013] Support metal C-joists, OWsJ, deep profile steel decks (over 50 mm in depth) without eccentric loading; and

[0014] In the case of the load-bearing walls supporting OWJ and C-joists, embody a reinforced concrete beam at the floor level as part of the wall systems.

Composite Beam Supporting OWsJs

[0015] In conventional post-and-beam construction with OWsJs, floor joists bear directly on the supporting beams, thus creating a space between the floor concrete and the supporting beams. This bearing detail is the only reason precluding the use of composite beam construction in the steel-joist-on-beam construction.

[0016] Rongue (U.S. Pat. No. 4,741,138) addressed this problem by providing extensions from the beam, through the decking and into the concrete, in an assembly utilizing beams, standard joists bearing on top of the beams, and metal decking onto which concrete is poured. The extensions are located in between OWsJs. The shear headed stads are field welded to the extensions through holes cut in the steel deck.
The limitations of this composite beam include the minimal thickness of cover concrete available for composite action, the expense of the extension, and the amount of welding required for composite action. For the foregoing reasons, there is a need for a composite beam construction system which provides an intermediate bearing element to support the joists and allows for the floor concrete to be in full contact with the steel beam along the full length of the beam, thus providing a deep concrete section—rather than merely a thin concrete deck—acting compositely with the steel beam.

Perimeter Stud Walls With Improved Impact Resistance

In post-and-beam construction, perimeter walls are often in-filled walls with metal studs. The in-fill walls are normally designed against wind loads only. In load-bearing metal stud wall construction, the perimeter walls are designed for gravity load as well as wind loads. In either case, perimeter stud walls are not designed for errant vehicles running into buildings. This invention will show an economical method of construction perimeter metal stud walls with improved resistance to impact from errant vehicles.

Composite Floor Construction With Concrete-Topped Deck on Open-Web Steel Joists

Concrete-topped steel deck on OWSJs constitutes the most common steel floor system. Many attempts have been made to further the efficiency of this system by integrating the OWSJs with the concrete on the steel deck for composite action.

U.S. Pat. No. 4,189,883 (McManus), and Canadian Patent Applications No. 2,404,535 (Moreau) and 2,441,737 (Moreau) disclose means of integrating the top chord of OWSJs and/or trusses with the concrete deck for improved horizontal shear resistance.


In Dutil’s system, each joist has a top chord forming a shear connector protruding into the concrete deck. Forming part of the top chord are two angles acting as shelves to receive steel decking. The deck acts as a form for pouring the slab, and is a permanent part of the composite floor system. Dutil’s system is commercially marketed under the name Hambro® joists by Canam.

Taft introduced a secondary truss-type framing member in which the top chord of the truss is formed in the shape of a modified “T” section having an upper flange, web and lower flange for supporting steel decking. The upper flange and web of the top chord are totally embedded in the concrete to cause the concrete floor and steel truss to function together structurally as a composite system.

Gjelsvik et al. describe OWSJs having tops chord comprising a pair of steel angles, and web members extending between the steel angles to the top of the vertical legs of the steel angles. Decking is supported by the horizontal legs of the top chords of adjacent joists, and a concrete slab is poured on the decking and between the vertical legs of the top chord to provide bonding between the concrete slab, top chord, and web.

All the above systems exhibit the following common features:

Steel deck is supported by shelves forming part of the joist top chord, and is discontinuous over the joist; and

Composite action is achieved by embedding the top chord in the concrete, which acts as a continuous shear connector (and in some cases is particularly shaped and/or embossed to achieve or enhance composite action.).

The use of shelves (usually in the form of angles) for deck support increases the cost of the composite open-web joist system in several ways:

Expensive shelf angles;

Discontinuous steel deck;

Excessive connections over joist support; and

Slower deck installation.

Accordingly, there is a need for a composite steel-deck-and joist floor construction that does not require deck-support shelves, and which enables continuous placement of steel deck.

Composite Steel Stud Walls

Light-gauge steel stud walls have been used extensively in a number of ways:

As infill walls in post-and-beam construction;

In load-bearing walls; and

In shear walls when sheathed in proper sheathing, usually in the form of plywood or oriented strand board (OSB).

In all cases, the steel stud walls are designed as hinged-supported at the top and bottom tracks.

In the construction of tall walls, attempts have been made to set light-gauge steel stud walls on top of concrete walls or masonry block walls, in the hope that the shorter steel stud length allows for lighter gauge steel to be used. However, the proper connections to the free-standing concrete wall or masonry wall require expensive details, in the absence of which a hinge joint forms at the junction of the lower concrete/masonry wall and the light-gauge steel stud wall, often leading to unsatisfactory performance or failure. Today, this practice has been all but abandoned.

A popular construction system with tall wall construction is the “tilt-up” construction method, in accordance with which reinforced concrete wall panels are cast flat on site, and then tilted up into vertical position to be connected to foundation elements. While this method may be advantageous a fast means of providing a building envelope, tilt-up walls typical provide poor insulation qualities at a limited choice of exterior wall finishes. Often an additional interior perimeter stud wall system is installed to provide the desired insulation and building envelope continuity.
For all the foregoing reasons, there is a need for a composite steel stud wall construction system in which at least one end of each stud has a significant degree of structural fixity (i.e., rotational resistance) rather than approximating a hinged connection as in prior art systems. Such a wall construction system would enable the use of lighter, more economical studs than would otherwise be required (in accordance with a “hinged end” stud design model), and would be particularly beneficial in practical applications including:

- Perimeter walls, both as load-bearing walls and as wind-bearing walls, requiring tall wall construction as in such building types as auditoriums, gymnasiums, etc.; and
- Perimeter structural walls and infill walls under windows in buildings exposed to high risk of impact from errant vehicles.

There is a further need for a composite stud wall building system that is adaptable to tilt-up construction, with advantages provided by conventional tilt-up construction in terms of speed of construction, but with improved insulation properties and adaptability for use with a wider variety of architectural finishes.

Stud Wall on Composite Deck Floor Construction

Fluted structural steel decks come in different depths, with the most commonly-used types having a 38 mm (1.5") depth. Medium-depth decks are 75 mm (3") in depth, whereas decks with depths greater than 75 mm (3") are usually referred to as deep profile decks, which may range from 200 mm to 300 mm (8" to 12") in depth. Steel deck may be plain (i.e., with all required structural strength being provided by the deck alone), or composite (i.e., with deformations formed into the deck to promote composite structural action with a concrete topping placed over the deck). Medium-depth and deep profile composite decks are often used to provide long spans between major supports (load-bearing walls or structural beams), without the need for intermediate joists.

In typical concrete-topped steel deck floor construction, deck installation and floor concrete placement must be completed before stud walls above the floor elevation may be constructed. This typically delays subsequent wall construction to allow for the curing of the floor concrete.

For the foregoing reasons, there is a need for an economical system way for constructing steel stud walls on top of fluted steel floor deck prior to placement of floor concrete.

**BRIEF SUMMARY OF THE INVENTION**

In one aspect, the present invention is a composite joist-and-deck floor construction system featuring the use of “shear-connection-ready” open-web steel joists (hereinafter referred to as “SCR-OWSJ s”), and in which shear connectors are fastened to the SCR-OWSJ after steel deck has been placed over the SCR-OWSJ. In a preferred embodiment of the system, each SCR-OWSJ is fashioned by attaching an elongate continuous steel cap plate to the top of the top chord of a conventional OWSJ (such as by welding, or other structurally effective fastening means). The field-installed shear connectors may be of any suitable type, spaced as required in accordance with well-known structural design principles. For example, the shear connectors may be conventional headed shear studs (e.g., Nelson studs) resistance welded or manually welded to the SCR-OWSJ through the steel deck, or shear connectors field-applied to the SCR-OWSJ through the steel deck using power-actuated or powder-actuated tools. Since the shear connectors are field installed after the floor deck is in place, the deck can be continuous over the SCR-OWSJ, rather than having to cut at each joist and supported on shelf angles.

Practical benefits available using the SCR-OWSJ floor construction system of the present invention include:

- Increased joist capacity and floor stiffness-or, alternatively, the ability to use lighter and more economical joists to achieve required structural strength and stiffness-through composite construction;
- Greater economy and faster installation of steel deck by virtue of continuity of steel deck over joist supports; and
- Easy adaptability to any type of conventional OWSJ and shop practice.

The SCR-OWSJ floor system of the present invention (the “SCR-OWSJ system”) may be used as a floor joist system by itself, or may be readily adapted for use with composite steel beam and load-bearing wall construction systems including but not limited to those described in Canadian Patent No. 2,407,253.

Preferably, the SCR-OWSJ incorporate joist seat extensions to facilitate direct bearings on support beams or walls, without need to interpose joist support elements between the joist seats and their support elements in order to achieve desired floor elevations. This facilitates the erection and positioning of SCR-OWSJ on the support beams or walls, since there are no obstructions (such as joist support elements or shear studs) present on the upper surfaces of these support elements when the SCR-OWSJ are being positioned. Shear connectors may be field-applied to both the SCR-OWSJ and supporting steel beams as required, using power-actuated or powder-actuated tools, after the SCR-OWSJ are in place. The advantages of this composite floor construction system include:

- Structural steel framing members may be erected in accordance with common erection practices, allowing for high-rise construction;
- The need for coordination between the structural steel and light-gauge steel trades is minimized; and
- Respective responsibilities of the structural steel and light-gauge steel trades are clearly delineated.

In another aspect, the present invention is a composite steel stud wall construction system in which the conventional bottom and/or top tracks are replaced with tracks with perforations in the web, or with pairs of bent plates or steel angles, to allow reinforcing dowels to project from a concrete support element (such as a concrete foundation wall). Infill concrete is placed within the stud assembly to a desired height above the bottom track (as determined by structural design requirements), such that the lower ends of the studs achieve a significant degree of structural fixity.
The result is a composite steel stud wall which can be analysed as an upper segment comprising the portions of the steel studs above the infill concrete, plus a composite segment comprising the infill concrete and the portions of the steel studs embedded therein, with effective structural continuity between the two segments.

The scope of the composite steel walls can be broadened by incorporating the current tilt-up construction or precast methods in their installation. In the tilt-up version, the light gauge steel component of the wall panels are either fabricated in a shop or site fabricated on flat, complete with the exterior cladding and window framing details. The concrete components are site cast into the light gauge steel stud wall panels in locations required by structural design. The wall panels are then tilt-up or otherwise lifted into place after the concrete has acquired the strength necessary to handle the stresses from the lifting operation. In the present version, all of the wall panel components are shop fabricated and delivered to site for installation.

Practical benefits available using the composite steel stud wall construction system of the present invention include:

Effective structural fixity of the steel stud wall, such that required structural strength and flexural stiffness can be provided using lighter studs than in conventional systems;

Ability to construct taller steel stud walls by varying the height of concrete embedment in the wall assembly;

Enhanced resistance to damage caused by impact from errant vehicles; and

The advantages of precast construction (either cast in the shop cast or on site for tilt-up construction), but with less weight for the wall panels, and providing better insulation and building envelope continuity as well as being amenable to a wide choice of architectural finishes.

In a third aspect, the present invention is a wall construction system for use in conjunction with a concrete-slab-on-steel-deck floor system, that enables load-bearing steel stud walls to be framed between floor levels before floor concrete has been poured, while also imparting a significant degree of structural fixity. Practical benefits available from the use of this system include:

The ability to construct steel stud walls directly on steel floor deck, thereby eliminating the need to wait for floor concrete to cure prior to wall construction; and

Reduced steel stud costs (and/or enhanced structural strength and stiffness) resulting from stud fixity at the bottom track location.

In a further aspect, the present invention is a shear-connection-ready open-web steel joist assembly comprising a steel truss having a top chord, a bottom chord, and a triangulated web system; and a steel plate overlaying and connected to the top chord.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying figures, in which numerical references denote like parts, and in which:

FIGS. 1A and 1B are sectional and elevation views, respectively, of an interior shear-connection-ready open-web steel joist (SCR-OWSJ) with an inverted hat section as top chord, in accordance with a first embodiment ("Embodiment 1") of the present invention.

FIGS. 2A and 2B are sectional and elevation views, respectively, of an interior SCR-OWSJ with double angle sections as top chord, in accordance with a second embodiment ("Embodiment 2") of the invention.

FIGS. 3A, 3B, and 3C are sectional, elevation, and isometric views, respectively, of exterior load-bearing wall panels for the support of concrete-topped steel deck on an SCR-OWSJ floor assembly, at a floor joint of a multi-storey structure, in accordance with a third embodiment ("Embodiment 3") of the invention.

FIG. 3D is an isometric view of a typical intermediate floor/wall joint detail in accordance with embodiment 3.

FIGS. 4A, 4B, and 4C are sectional, elevation, and isometric views, respectively, of interior load-bearing wall panels for the support of concrete topped steel deck on an SCR-OWSJ floor assembly, at a floor joint of a multi-storey structure, in accordance with a fourth embodiment ("Embodiment 4") of the invention.

FIG. 4D is an isometric view of a typical intermediate floor/wall joint detail in accordance with Embodiment 4.

FIGS. 5A, 5B, and 5C are sectional, elevation, and isometric views, respectively, of an exterior composite beam for the support of concrete-topped steel deck on SCR-OWSJ floor assembly, in accordance with a fifth embodiment ("Embodiment 5") of the invention.

FIG. 5D is an isometric view of a typical intermediate floor/wall joint detail in accordance with Embodiment 5, and also illustrating an exterior steel stud wall installed prior to floor concreting.

FIGS. 6A, 6B, and 6C are sectional, elevation, and isometric views, respectively, of an interior composite beam for the support of concrete-topped steel deck on SCR-OWSJ floor assembly, at a floor joint of a multi-storey structure, in accordance with a sixth embodiment ("Embodiment 6") of the invention.

FIG. 6D is an isometric view of a typical intermediate floor/wall joint detail in accordance with Embodiment 6.

FIGS. 7A, 7B, and 7C are sectional, elevation, and isometric views, respectively of an exterior composite steel stud wall in accordance with a seventh embodiment ("Embodiment 7") of the invention.

FIGS. 8A, 8B, and 8C are sectional, elevation, and isometric views, respectively, of a tall load-bearing composite steel stud wall in accordance with an eighth embodiment ("Embodiment 8") of the invention.

FIG. 8D is a further isometric view of a tall load-bearing composite steel stud wall in accordance with Embodiment 8.

FIGS. 9A, 9B, and 9C are sectional, elevation, and isometric views, respectively, of an exterior composite steel
stud wall in accordance with a ninth embodiment ("Embodiment 9") of the invention, under a row of windows.

(0085) FIG. 9D is a further isometric view of an exterior wall in accordance with Embodiment 9.

(0086) FIGS. 10A, 10B, and 10C are sectional, elevation, and isometric views, respectively, of exterior load-bearing wall panels for the support of concrete-topped deep profile composite deck floor assembly, at a floor joint on the perimeter of a multi-storey building, in accordance with a tenth embodiment ("Embodiment 10") of the invention.

(0087) FIG. 10D is an isometric view of a typical intermediate floor/wall joint detail in accordance with Embodiment 10, in conjunction with a concrete-topped deep-profile composite deck floor system at an exterior load-bearing wall.

(0088) FIG. 11A is an exploded view of SCR-OWSJJs supported on an exterior beam, with bent-plate interior and exterior closure members for connection to the beam between OWSJ bearings.

(0089) FIG. 11B is an exploded view of SCR-OWSJJs supported on an interior beam, with Z-closure members for connection to the beam between OWSJ bearings.

(0090) FIGS. 12A and 12B illustrate an alternative base track comprising a pair of spaced angles, in conjunction with a load-bearing wall constructed, respectively, on a concrete foundation and on deep-profile floor decking.

(0091) FIG. 13A is a section through a composite steel stud bearing wall in accordance with an alternative embodiment of the invention, supporting roof joists and floor joists.

(0092) FIG. 13B is an elevation of a composite steel stud wall as in FIG. 13A, illustrating stud framing and reinforcements around wall openings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments 1 & 2: SCR-OWSJ

(0093) FIGS. 1A and 1B illustrate a shear-connection-ready open-web steel joist 20 (SCR-OWSJ) in accordance with one embodiment of the present invention. SCR-OWSJ 20 comprises a conventional OWSJ 5 with an elongate and substantially continuous cap plate 22 welded to the top surface of the top chord 5.1 of OWSJ 5. The substantial continuity of cap plate 22 allows corrugated steel deck 6 to be run continuous over SCR-OWSJ 20, with no need to cut deck 6 at joist locations and thus no need for deck-supporting shelf angles. At the same time, cap plate 22 provides a structural element to which shear connectors 15 can be welded (or otherwise attached) after steel deck 6 is in place, with the shear connectors 15 being positioned in selected lower flutes 6.1 of deck 6 as shown in FIG. 1B, and preferably in the plane of the associated SCR-OWSJ 20. Concrete can then be poured over the deck to form a floor slab 7, while at the same time encasing shear connectors 15 to achieve composite structural action between SCR-OWSJ 20 and floor slab 7.

(0094) In the embodiment shown in FIGS. 1A and 1B (Embodiment 1), OWSJ 5 is shown as a conventional type having an inverted hat-shaped top chord 5.1. In the alternative embodiment shown in FIGS. 2A and 2B (Embodiment 2), SCR-OWSJ 20 incorporates an OWSJ 18 of a conventional type having a top chord 18.1 formed by a pair of structural angles. However, the top chord profiles shown in both FIGS. 1A and 2A are solely for exemplary purposes, and it is to be understood that SCR-OWSJ 20 does not require the use of any particular type of top chord.

(0095) It is also to be understood that while cap plate 22 can most conveniently be provided in a single length, this is not essential to the invention. Cap plate 22 can be alternatively comprise two or more discontinuous lengths (i.e., not directly joined to each other) provided that any gaps between the discontinuous lengths are small enough not to impair proper support for any coincident lower flutes 6.1 of steel deck 6 (or provided that any such gaps occur below upper flutes 6.2 of deck 6). As well, each discontinuous length of cap plate 22 must be welded or otherwise connected to the top chord (5.1 or 18.1) with sufficient strength to safely transfer horizontal shear forces from all shear connectors 15 fastened to that discontinuous length, from the discontinuous length to the top chord. Of course, the same basic principle applies in the case of a single-length cap plate 22, and persons skilled in the art can readily design suitable weldments (or other forms of connection) in accordance with well-known structural engineering principles.

Embodiment 3: SCR-OWSJ on Exterior Load-Bearing Wall

(0096) FIGS. 3A, 3B, 3C, and 3D illustrate details of a floor-to-wall connection in accordance with the present invention (Embodiment 3), wherein an exterior light-gauge steel-stud load-bearing (LBW) wall 30 supports a "concrete-topped steel-deck-on-SCR-OWSJ" floor system. Lower LBW 30 comprises a plurality of light-gauge steel studs 32 extending between a light-gauge steel top track 2 and a bottom track (not shown). An upper LBW 40 comprises:

(0097) a light-gauge steel top track 41 (not shown);

(0098) an U-shaped light-gauge steel base track 50, comprising a continuous web member 52 having an inner face 52A and an outer face 52B, a continuous inner flange 54, and a continuous outer flange 56, with:

(0099) inner flange 54 and outer flange 56 being parallel and extending substantially perpendicularly from inner face 52A of web 52;

(0100) inner flange 54 having a plurality of cutouts 55, each shaped to receive a structural joist; and

(0101) base track 50 being positioned upon and connected to top track 2 of lower LBW 30, with inner flange 54 and outer flange 56 projecting vertically upward;

(0102) a plurality of joist-support elements 3, each positioned on inner face 52A of web member 52 of base track 50 adjacent to a corresponding cutout 55 in inner flange 54; and

(0103) a plurality of light-gauge steel studs 42 extending between base track 50 and top track 41, with each stud 42 having one or more web perforations 44 at selected locations near the lower ends of studs 42.

(0104) As shown in FIG. 3D, the ends of SCR-OWSJ 20 extend through cutouts 55 in inner flange 54 of base track 50
and supported on corresponding joist-support elements 3. Steel deck 6 is then installed on top of the SCR-OWSJs 20 and concrete floor slab 7 is poured on top of steel deck 6 (as previously described). As may be seen from FIGS. 3A-3D inclusive, inner flange 54 of base track 50 terminates at the underside of deck 6 (which is stopped at or close to inner flange 54), and outer flange 56 terminates at the finished floor elevation. Outer flange 56 thus serves as a form for the outer edge of slab 7, which in turn incorporates a concrete spandrel beam 60 within upper LBW 40, and extending from the top of slab 7 down to web 52 of base track 50. Web perforations 44 in studs 42 allow concrete to flow between studs 42, and also enable reinforcing bars 13 to be placed within base track 50 to suit the structural requirements of spandrel beam 60, in accordance with specific project requirements.

[0105] Spandrel beam 60 also encases the lower ends of studs 42, thus imparting a significant degree of fixity thereto; this allows studs 42 to be lighter for given vertical and lateral loads than would be required for studs having no significant end fixity (i.e., hinge joints).

[0106] In the Figures, joist-support elements 3 are shown as pieces of rectangular steel tubing, oriented to allow free passage of concrete (and reinforcing bars 13, if required). However, persons skilled in the art will appreciate that joist-support elements 3 could take various other forms without departing from the basic concepts of the present invention.

[0107] In addition to the structural benefits achievable through use of the above-described system, there is a further advantage in that it allows LBWs to be constructed before the floor slab 7 poured, thus providing flexibility with respect to the timing of floor concrete placement operations, and facilitating earlier enclosure of the building (since additional wall construction does not have to wait for the floor slab to be placed and cured). In fact, the system makes it possible to defer floor concrete placement until the building is completely enclosed, thus allowing reducing hoarding and/or temporary heating costs for buildings being built in harsh climatic conditions.

[0108] Although Embodiment 3 has been illustrated and described in association with the use of SCR-OWSJs 20, it will be appreciated that the system can be readily adapted for use with conventional OWSJ or other types of floor joists (with or without shear connectors for composite action with floor slab 7). It will also be appreciated that the basic concepts described in connection with Embodiment 3 can be readily adapted for construction of upper LBW 40 on different types of lower LBW (e.g., masonry or wood-framed walls) rather than on a steel stud wall 30 as illustrated.

Embodiment 5: SCR-OWSJ on Exterior Steel Beam

[0111] Embodiment 5 of the invention, illustrated in FIGS. 5A, 5B, 5C, and 5D, is a variant of Embodiment 3, but with exterior LBW 40 being constructed on top of a structural beam 14 at an exterior building location rather than on a lower exterior LBW. Except as noted, other details of Embodiment 5 are the same as described and shown in connection with Embodiment 3 (FIGS. 3A, 3B, 3C, and 3D). Beam 14 may be a steel beam as shown in FIGS. 5A, 5B, 5C, and 5D (with or without shear connectors 15 for composite action between beam 14 and slab 7), but the basic concept can be readily adapted for use with other types of structural beams (e.g., cast-in-place concrete, precast concrete, or timber beams).

[0112] Although Embodiment 5 has been described with specific reference to an exterior steel stud LBW 40, the exterior wall is not essential. The floor systems described herein work equally well in conjunction with alternative exterior wall systems that lie totally outside of the exterior base track 50 (e.g., curtain walls and precast wall panels).

Embodiment 6: SCR-OWSJ on Interior LBW

[0113] Embodiment 6, as illustrated in FIGS. 6A, 6B, 6C, and 6D, is a variant of Embodiment 4, but with exterior LBW 40 being constructed on top of a structural beam 14 at an interior location rather than on a lower interior LBW. Except as noted, other details of Embodiment 6 are the same as shown and described in connection with Embodiment 4 (FIGS. 4A, 4B, 4C, and 4D). Beam 14 may be a steel beam as shown in FIGS. 6A, 6B, 6C, and 6D (with or without shear connectors 15 for composite action between beam 14 and slab 7), but the basic concept can be readily adapted for use with other types of structural beams (e.g., cast-in-place concrete, precast concrete, or timber beams).

Embodiment 7: Composite Steel Stud Walls

[0114] In conventional steel stud wall construction, the studs are designed as hinge-supported at both the top and the bottom track locations. While this approach has wide applications, situations arise where the walls are too high for economical steel stud use, or where the need for impact resistance rules out steel stud wall construction.

[0115] Examples of buildings requiring tall wall construction would include gymnasiums, auditoriums, and ware-
houses requiring high clearance. Masonry walls have traditionally been the wall assembly of choice for these building types.

[0116] Examples of building types requiring walls with high impact resistance would include manufacturing and fabrication shops with forklifts or mobile equipment, as well as buildings with high exposure to vehicle traffic. Concrete or masonry walls have traditionally been the wall assembly of choice for walls requiring high impact resistance.

[0117] FIGS. 7A, 7B, and 7C illustrate a composite steel stud wall 70 in accordance with Embodiment 7 of the present invention. Composite stud wall 70 comprises:

[0118] a perforated channel-shaped base track 72 comprising a web 74 extending between two flanges 76, with web 74 having a plurality of spaced dowel openings 75, with base track 72 being supported on a concrete or concrete-filled support element 80 (e.g., a concrete grade beam, or a concrete or grouted concrete block wall); and

[0119] a plurality of spaced light-gauge steel studs 42 as described in connection with Embodiment 3 (i.e., with web perforations 44 at selected locations near the lower ends of studs 42), inserted between and extending upward flanges 76 of base track 72.

[0120] Reinforcing steel dowels 82 projecting upward from support element 80 extend through dowel openings 75 in base track web 74 at locations and heights as dictated by structural design criteria. Formwork 16 (either temporary or permanent) is positioned on each side of base track 72 and studs 42 and concrete is placed inside formwork 16 to a desired height above support element 80 (to suit structural design requirements), with web perforations 44 allowing concrete to flow between studs 42. This creates a composite steel stud wall 70 incorporating a reinforced concrete pony wall 84 projecting upward from support element 80. The lower portions of studs 42 are thus embedded within pony wall 84, and thus become substantially “fixed” from a structural analysis standpoint. Composite steel stud wall 70 can thus be structurally analyzed as comprising two segments—(1) an upper segment comprising the upper portions of steel studs 42 and (2) a composite segment comprising concrete pony wall 84 and the portions of studs 42 embedded therein, with no loss of structural continuity between the segments. If desired or required for structural reasons, horizontal reinforcing bars 13 can be inserted through web perforations 44 of studs 42 before placement of concrete for pony wall 84.

Embodiment 8: Tall Composite Load-Bearing Wall

[0121] Embodiment 8 of the invention, as shown in FIGS. 8A, 8B, 8C, and 8D, is a variant of Embodiment 7, adapted for tall wall applications, and except as noted, the construction details are generally the same as described and shown in connection with Embodiment 7. The light-gauge steel stud wall is erected on support wall 80, with base track 10 anchored to support wall 80 with anchor bolts 21 or other suitable means. Studs 42 are designed for full design wind loading only, under the assumption of full fixity and composite action through the height of concrete pony wall 84. Formwork 16 (which could be in the form of permanent wall sheathing 8) is positioned on both sides of studs 42 to specified elevations, wherein concrete is placed within formwork 16 to form pony wall 84. Incorporated into the wall at roof joist 95 locations are compression members (not shown) each built from multiple bundled steel studs, designed solely for vertical loading assuming full fixity and composite action through the height of concrete pony wall 84. Concrete can be scheduled after the building is enclosed. Temporary bracing will typically be required for studs 42 and the built-up compression members until pony wall 84 has cured sufficiently.

Embodiment 9: Composite Stud Wall for Improved Impact Resistance

[0122] Embodiment 9 of the invention, as shown in FIGS. 9A, 9B, 9C, and 9D, shows how the construction described and shown in connection with Embodiment 7 (FIGS. 7A, 7B, and 7C) can be adapted to situations where resistance to damage from vehicular impact is important, and particularly where an exterior wall has a row of windows (such as in a drive-through restaurant). In this case the wall construction is generally the same as for Embodiment 7, except that concrete pony wall 84 extends to the underside of the window opening, and the studs 42 below the opening have perforations 44 spaced along their full length, to allow concrete to flow between studs 42. This construction, properly designed for predictable structural loads, makes it unnecessary to reinforce the horizontal upper track 2 forming the sill of the window opening, because the reinforced composite wall under the window-effectively acting as flexural element cantilevering from the foundation wall-will adequately resist lateral loads (from both wind and vehicular impact) acting on the wall below the window opening.

Embodiment 10: Steel Stud Wall Construction on Composite Deck

[0123] FIGS. 10A, 10B, 10C, and 10D illustrate a construction system for use in conjunction with a concrete-slab-on-steel-deck floor system using deep-profile steel deck, and enabling load-bearing steel stud walls to be framed between floor levels before floor concrete has been poured. After a lower load-bearing steel stud wall 30 has been constructed, a closure track 12 is installed on top of top track 2 of lower LBW 30, and deep-profile steel floor deck 11 (plain or composite) is installed, with the lower surfaces of the deck flutes being supported on closure track 12. Tie straps or other suitable tie means (not shown) are installed to secure the outer leg of closure track 12 to deck 11. An upper stud wall 40A may then be constructed, with the base track 10 of upper wall 40A being supported on the upper surfaces of deck 11. The horizontally-oriented web of base track 10 of upper wall 40A has perforations 15 spaced to match the flutes of deep-profile steel floor deck 11, so that reinforcing dowels 13 can extend from the deck flutes spaces through the base track web perforations 15. When floor concrete is subsequently placed, it will encase reinforcing dowels 13 projecting into the stud wall assembly, while also encasing base track 10, imparting a degree of fixity to the lower ends of the upper wall studs 42. This fixity may be enhanced by allowing the floor concrete to extend within the upper wall stud assembly to a desired height above the finished floor level.
Embodiment 11 Composite Floor System with Composite Beam, SCR-OWSJ and Field-Installed Shear Connectors

[0124] FIGS. 11A and 11B illustrate, respectively, exterior and interior beam bearing details for and alternative composite floor construction system using a variant SCR-OWSJ 90 with Z-shaped interior closure sections 94 and L-shaped exterior closure angles 96, bent from light-gauge steel plates and mounted to the support beams between SCR-OWSJ bearing locations. Variant SCR-OWSJ 90 is essentially the same as the basic SCR-OWSJ 20 previously described, but has an elevated or extended joist seat 91 and a light-gauge steel closure plate 92. Heightened joist seat 91 eliminates the need for independent joist support elements 3 as shown in connection with Embodiments 3, 4, 5 and 6, and shop-fitted closure plate 92 eliminates the need for closely-fitting joist cutouts 55 in a continuous base track 50 as shown for Embodiments 3, 4, 5 and 6.

[0125] The bottom flange 94A if interior Z-closure plate 94 is welded or otherwise connected to the supporting steel beam 14. The upper flange 94B of interior Z-closure plate is connected to the top of steel deck 6 (not shown in FIGS. 11A and 11B). Exterior closure angles 96 are preferably shop-fabricated to maximum practical length, but could also be provided in shorter lengths and spliced in the field. The horizontal lower leg 96A of exterior closure angle 96 is welded or otherwise connected to the supporting steel beam 14, and the vertical leg 96B of exterior closure angle 96 preferably terminates at the finished floor elevation. The tops of closure angles 96 may be tied to support beam 14 at regular intervals with light-gauge strap ties (not shown).

[0126] The use of variant SCR-OWSJ 90 with interior Z-closure plates 94 and exterior closure angles 96 enables the system to be constructed using current structural steel erection practices, without overlap between related trades. The structural steel trade erects columns and beams, lifts the SCR-OWSJs in bundles and spreads them along the beams to their correct locations before welding them down to the beams. Then and only then need the light-gauge steel trade be on site for installation of decking, closure tracks and ties, perimeter wall studs and sheathing, and shear connectors to decks and beams.

[0127] The advantages of this new composite floor system with field-installed shear connectors to both beams and SCR-OWSJ's include:

[0128] Composite action is maintained;
[0129] Concrete pour can be postponed after the perimeter walls are installed;
[0130] No extra coordination is required between the structural steel and light-gauge steel trades; and
[0131] No changes is required to current erection practices or delineation responsibilities.

Embodiment 12—Pair of Bent Plates as Base Tracks

[0132] FIGS. 12A and 12B illustrate the use of pairs of bent plates 99A to form a base track 98 in lieu of the web-perforated base track 72 of Embodiments 7, 8, 9, and 10. Bent plates 99A are laterally spaced to allow for downward passage of concrete, and upward projection of dowels.

[0133] FIG. 12A specifically illustrates the use of bent plates 99A to form a base track 98 in a Composite Tall Wall application, with dowels 82 projecting from the foundation concrete element. FIG. 12B shows this alternative base track construction in conjunction with a deep-profile floor deck 11, with the lateral spacing between the pair of bent plates 98A allowing the floor concrete 7 to flow through to fill up the deep profile deck.

Embodiment 13—Precast Composite Stud walls

[0134] FIGS. 13A and 13B illustrate, in section and elevation respectively, composite steel stud walls 70 supporting roof joists 95 and floor joists 20. The concrete in composite steel stud walls 70 can be either site-cast, or composite walls 70 can be precast in the shop and delivered to site as completed wall panels 71.

[0135] The top tracks of panels 71 may be formed by a pair of steel angles 77 complete with anchorage studs. The angles 77 allow for support of the joists by direct welding, the depth of the concrete in-fill and reinforcing details are determined by structural design requirements. Dowels 82 may be installed as part of the precast composite panel for connection to the wall panels above.

[0136] Headers 79 over windows or other openings can be formed by box beams framed with light-gauge steel materials, or may be reinforced concrete headers forming integral parts of the precast concrete wall panels 71.

[0137] The bottom tracks of the wall panels may comprise interior and exterior closure plates 94 and 96 respectively as in Embodiment 11. Floor concrete 7 flows into the closure plates to provide a solid inter-panel connection.

[0138] The precast composite stud wall system described above offers advantages over current practice including the following:

[0139] Savings in volume of concrete, as concrete is cast only where it is needed for structural strength;
[0140] With savings in concrete come savings in curing, shipping, and handling;
[0141] A better building envelope with increased insulation value and envelope continuity, and offering a wider choice of architectural finishes; and
[0142] Capability to integrate with most structural floor systems, including the composite joist floor systems detailed in this patent specification.

[0143] It will be readily appreciated by those skilled in the art that various modifications of the present invention may be devised without departing from the essential concept of the invention, and all such modifications are intended to be included in the scope of the claims appended hereto. It is to be especially understood that the invention is not intended to be limited to the illustrated embodiments, and that the substitution of a variant of a claimed element of feature, without any substantial resultant change in the working of the invention, will not constitute a departure from the scope of the invention.

[0144] In this patent document, the word “comprising” is used in its non-limiting sense to mean that items following that word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite
article “a” does not excluded the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one such element. WHAT IS CLAIMED IS:

1. a wall assembly constructed upon a support surface, said assembly comprising:

(a) an elongate light-gauge metal base track comprising a continuous web member having an inner face and an outer face, a continuous first flange, and a continuous second flange, wherein:

a.1 said first and second flanges are parallel and extend substantially perpendicularly from the inner face of the web member; and

a.2 the first flange has a plurality of cutouts, each shaped to receive a structural joist;

said base track positioned upon and anchored to the support surface, with its first and second flanges projecting vertically upward;

(b) a plurality of joist-support elements, each positioned upon the inner face of the base track’s web member adjacent a corresponding joist cutout; and

(c) a wall panel comprising a plurality of spaced, light-gauge metal studs, the lower ends of said studs being disposed between the base track’s first and second flanges.

2. The wall assembly of Claim 1 wherein at least one of the cutouts in the base track’s first flange is configured to receive an open-web steel joist.

3. The wall assembly of Claim 1 wherein the upper edge of the base track’s second flange coincides with a selected floor elevation.

4. The wall assembly of Claim 1 wherein the base track’s second flange has a plurality of cutouts, each shaped to receive a structural joist.

5. The wall assembly of Claim 1 wherein at least one of the studs has a perforation for receiving a concrete reinforcement rod, said perforation being positioned below the upper edge of the base track’s second flange.

6. The wall assembly of Claim 1 wherein the support surface is the top track of a lower wall.

7. The wall assembly of Claim 1 wherein the support surface is the top flange of a structural steel beam.

8. The wall assembly of Claim 7 further comprising a plurality of shear connectors anchored to the top flange of the steel beam, said shear connectors being spaced apart and positioned between the studs of the wall panel.

9. A wall-and-floor subassembly comprising:

(a) a wall constructed upon a support surface and comprising:

a.1 an elongate light-gauge metal base track comprising a continuous web member having an inner face and an outer face, a continuous first flange, and a continuous second flange, wherein said first and second flanges are parallel and extend substantially perpendicularly from the inner face of the web member, and wherein the first flange has a plurality of cutouts, each shaped to receive a structural joist, said base track being positioned upon and anchored to the support surface, with its first and second flanges projecting vertically upward;

a.2 a plurality of joist-support elements, each positioned upon the inner face of the base track’s web member adjacent a corresponding joist cutout; and

a.3 a wall panel comprising a plurality of spaced, light-gauge metal studs, the lower ends of said studs being disposed between the base track’s first and second flanges;

(b) a plurality of primary floor joists each having:

b.1 a first end disposed within one of the joist cutouts in the base track’s first flange, and supported on a corresponding joist-support element; and

b.2 a second end supported on a first auxiliary support structure, such that the top surfaces of the primary joists lie in a common horizontal plane;

(c) metal decking overlying and fastened to the primary joists; and

(d) concrete topping placed over the metal decking and extending into the space between the first and second flanges of the base track, with the upper surface of the concrete topping being at a selected floor elevation.

10. The wall-and-floor subassembly of Claim 9 wherein the upper edge of the base track’s second flange coincides with a selected floor elevation.

11. The wall-and-floor subassembly of Claim 9 wherein:

(a) the base track’s second flange has a plurality of joist cutouts;

(b) the subassembly further comprises a plurality of supplementary floor joists, each having a first end disposed within one of the joist cutouts in said second flange, and supported on a corresponding joist-support element, and having a second end supported on a second auxiliary support structure, such that the top surfaces of the supplementary joists lie in the same plane as the primary joists; and

(c) the metal decking overlies and is fastened to both the primary and supplementary joists.

12. The wall-and-floor subassembly of Claim 8 wherein at least one of the studs has a perforation for receiving a concrete reinforcement rod, said perforation being positioned below the upper edge of the base track’s second flange.

13. The wall-and-floor subassembly of Claim 9 wherein the support surface is the top track of a lower wall.

14. The wall-and-floor subassembly of Claim 9 wherein the support surface is the top flange of a structural steel beam.

15. The wall-and-floor subassembly of Claim 14, further comprising a plurality of shear connectors anchored to the top flange of the steel beam, said shear connectors being spaced apart and positioned between the studs of the wall panel.

16. A wall-and-floor subassembly constructed upon a support surface, said assembly comprising:

(a) an elongate light-gauge metal base track comprising a continuous web member having an inner face and an outer face, a continuous first flange, and a continuous second flange, wherein:
a.1 said first and second flanges are parallel and extend substantially perpendicularly from the inner face of the web member; and

a.2 the horizontally disposed web member has a plurality of perforations spaced to align with the flute spacing of the fluted structural deck upon which the said base track is placed.

said base track being positioned upon and anchored to the support surface, with its first and second flanges projecting vertically upward;

(b) a wall panel comprising a plurality of spaced, light-gauge metal studs, the lower ends of said studs being disposed between the base track’s first and second flanges;

(c) a plurality of elongate fluted structural decking units spanning between said decking support means and an auxiliary support means, with the upper surfaces of the decking units being at a common elevation, and

(d) concrete topping placed over the metal decking and extending into the space between the first and second flanges of the base track, with the upper surface of the concrete topping being at a selected floor elevation.

17. The wall assembly of Claim 16 wherein the support surface for the said wall panel is the surface of the high flutes of a light-gauge steel deck, having the low flutes of the said steel deck aligned with the perforations in the web of the base track.

18. The wall-and-floor subassembly of Claim 16 wherein the support surface is the top track of a lower wall.

19. The wall-and-floor subassembly of Claim 16 wherein at least one of the studs has a perforation for receiving a concrete reinforcement rod, said perforation being positioned below the upper edge of the base track’s second flange.

20. The wall-and-floor subassembly of Claim 16 wherein the support surface is the top flange of a structural steel beam.

21. The wall-and-floor subassembly of Claim 20, further comprising a plurality of shear connectors anchored to the top flange of the steel beam, said shear connectors being spaced apart and positioned between the studs of the wall panel.

22. A wall assembly constructed upon a support surface, said assembly comprising:

(a) an elongate light-gauge metal base track comprising a continuous web member having an inner face and an outer face, a continuous first flange, and a continuous second flange, wherein:

a.1 said first and second flanges are parallel and extend substantially perpendicularly from the inner face of the web member; and

a.2 the horizontally disposed web member has a plurality of perforations; said base track being positioned upon and anchored to the support surface, with its first and second flanges projecting vertically upward; and

(b) a wall panel comprising a plurality of spaced, light-gauge metal studs, the lower ends of said studs being disposed between the base track’s first and second flanges;

wherein the lower end of the wall panel is sheathed with sheathing of sufficient rigidity to provide formwork for concrete infill inside the said wall panel.

23. The wall assembly of Claim 22 wherein the support surface is the top surface of the foundation structure.

24. The wall assembly of Claim 23, further comprising reinforcing dowel bars protruding from the foundation structure through the perforations of the base track.

25. The wall assembly of Claim 24, further comprising concrete infill inside of the wall assembly to a selected height.

26. The wall assembly of Claim 25, further comprising a top track of sufficient rigidity to distribute loading from a structural joist to the adjacent studs.