and reduced wear. Monorail beams supported by hanger rods always require antisway lateral bracing for stability. Any suspension system should be vertically adjustable to bring the monorail beams to a true horizontal position prior to installation of the lateral bracing. Obviously, flexible suspension makes adjustments easier.

The side thrust *S* has been traditionally resisted by a shop-welded channel laid flat on top of an I beam (Fig. 15.3). The proprietary track, with its wide top flange, makes the channel unnecessary. The side thrust can also be resisted by intermittent lateral bracing of the girder's top flange; such bracing must be designed not to interfere with vertical deflection of the monorail beam. Lateral bracing of this sort might be impractical in pre-engineered buildings with cold-formed purlins: the purlins have little lateral stability of their own and cannot accept bracing loads. Some additional structural members must then be introduced to resist the lateral bracing forces, or adequate lateral bracing provided between the purlins to distribute these forces into the roof diaphragm.

The longitudinal runway force *L* may be resisted by a diagonal angle brace located in the plane of the monorail beam at approximately 100-ft intervals and at all runway turns.[5] Again, some added structural members (or at least boxed headers placed between the purlins) are needed to resist the bracing forces.

The locations and conceptual details of all vertical and lateral supports should be indicated in the contract documents. The vertical supports should ideally occur at each main frame or at 20- to 25-ft intervals if the monorail runs alongside the frame. A special case arises when two parallel monorail beams must transition into a single perpendicular beam. This problem can be solved with monorail switches.

15.4.4 Design Considerations for Runway Beams

ANSI MH 27.1 requires that the allowable stress in the lower (tension) flange of monorail runway beams be limited to 20 percent of the ultimate steel strength. It also specifies the deflection criterion for monorail runway beams with spans of 46 ft or less as the length between vertical supports divided by 450. The *L*/450 deflection criterion is also found in other sources, including the MBMA Manual.

Monorail beams must be carefully spliced to allow for smooth wheel movement between the individual beams. The best splice detail involves full-penetration welding of the bottom flange in combination with bolted shear plates in the web. Some pre-engineered manufacturers prefer to use field-welded tie plates and locate the splices under each hanger (Fig. 15.6). To ensure that the splice does not interfere with the trolley travel, it is wise to require a test run of the trolley through the whole length of the monorail before accepting the work.

Who supplies the runway beam and its supports? The metal building manufacturer already provides the suspension supports and could also provide the runway beam if specifically required to do so by contract (normally, crane work is excluded from the manufacturer's scope of work). The runway beam supplied by a building manufacturer is likely to be of standard structural shape. Whenever proprietary runway beams or switches are specified, they should be furnished and installed by the monorail supplier.

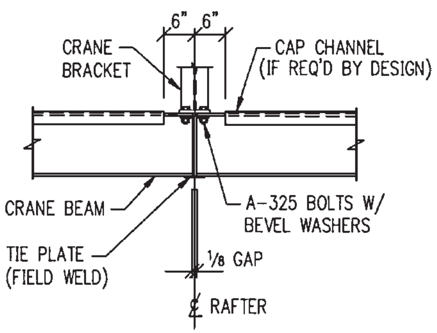

FIGURE 15.6 Runway beam splice at hanger locations. (*Metallic Building Systems.*)

15.4.5 Special Requirements for Supporting Frame Rafters

Whichever suspension system is selected, the weight of the loaded monorail needs to be transferred into the supporting frame rafter. A suspended load that attempts to tear the bottom flange of the rafter away from its web must be resisted by welds between the flange and the web; the web tearing is resisted by stiffeners (Figs. 15.3, 15.4, and 15.5).

Pre-engineered building manufacturers usually provide single-side web-to-flange welds in their primary frames. Such welds may be inadequate to resist high localized suspended loads. The built-up rafters welded on only one side and subjected to cyclical suspended loads may suffer from fatigue problems caused by a notch which is sometimes produced by one-sided welding.[11] For this reason, the areas around the hangers may have to be reinforced with double-sided welds, to act in combination with web stiffeners in resisting the suspended loads. Occasionally a large part of the frame may have to be reinforced with double welds. This nuance is just one more reason to coordinate the design of metal-building and overhead-crane systems.

Loads acting on the metal building system from monorails, or from any other crane supported by the building structure, should be entered into the loading combinations discussed in Chap. 3.

15.5 UNDERHUNG BRIDGE CRANES

15.5.1 System Description

An underhung bridge crane, as the name implies, features a hoist trolley that moves along the crane bridge "hung" from the runway beams. The crane bridge is usually a single, and occasionally double, girder supported by two end trucks with wheels running on the bottom flanges of the runway beams (Fig. 15.7). The runway beams, in turn, are suspended from the building frame rafters or trusses. (In the latter case, supports are at the truss panel points.) A minimum clearance of 2 in is required by ANSI MH 27.1 between the underhung crane and any lateral or overhead obstruction.

Underhung bridge cranes have relatively modest lifting capacities—from 1 to 10 tons—and are usually confined to spans of 20 to 50 ft. According to metal building manufacturers, framing for underhung cranes is more economical than for top-running cranes, and 5-ton cranes should generally be of the underhung design. Both hand-geared and electric-powered underhung cranes are available. The electric cranes are usually controlled by a pendant pushbutton station, although cab-operated and automatically controlled underhung cranes exist, too.

The chief advantage of the underhung design lies in the fact that the crane span need not extend all the way between the building columns. Thus underhung cranes are especially appropriate when only a part of the building aisle needs crane service and when the building has a large clear span. The underhung design allows the trolley to travel beyond the centerlines of the runway beams and permits load transfer between the adjacent crane aisles or between several parallel underhung cranes in one aisle.

15.5.2 Runway Beams

Design and construction of runway beams for underhung cranes are similar to those of monorails. Both types of cranes traditionally relied on runways made of I beams (now called S shapes) with

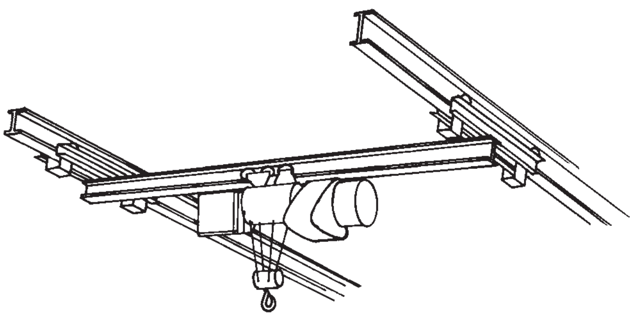

FIGURE 15.7 Underhung single-girder crane. (*FKI Industries, Inc.*)