THE "SMART" SOLUTION

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Castellated beams have been used as structural members in the Europe and the United States since the early 1900's. The theory behind the castellated beam is to increase the beam's depth and strength without adding additional material. Prior to automated cutting and welding technology, the manufacturing process used to make castellated beams was to cut the beam apart and weld them back together manually. This was labor intense and costly. With rising labor costs, expanded production, gained efficiencies and advancement in manufacturing of rolled shapes, the use of castellated beams had been abandoned until recently. SMI began manufacturing their version of the castellated beam, the SmartBeam™, about 18 months ago with a single target market in mind; Composite Floor Beams.

Manufacturing Process

SmartBeams are manufactured by cutting a WF beam in a zigzag pattern along the web with an automated computer-controlled plasma torch, separating the two halves, then welding the web post back together at the high points with an automated submerged arc welding process as shown in Fig. 1. This process increases the depth of the beam by approximately 50%, therefore increasing the strength and stiffness by 40%. An original W18x35 after castellation becomes a CB27x35 with openings spaced uniformly along the web. The beams are welded back together with camber build in, therefore eliminating a costly offline cambering process.

SmartBeam Design

The SmartBeam design is very similar to that of Vierendeel truss design in that the shear component creates bending through the web openings that has to be accounted for in the bending stress calculations. The design procedure for castellated beams is shown in detail in a time tested and respected publication, *The Design of Welded Structures*, by Omar Blodgett. There are 3 basic design checks in designing castellated beams.

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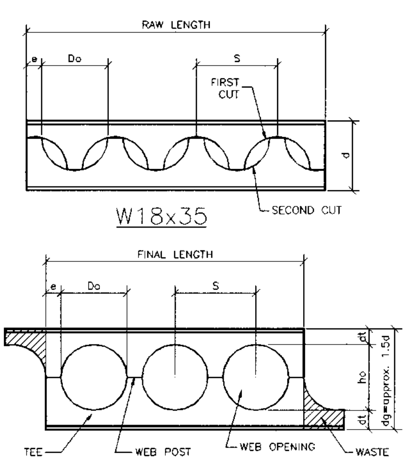

figure 1

Vierendeel Bending

Vierendeel bending is a combination of true bending and vierendeel bending created by shear transfer across the web openings as shown in Fig. 2. The primary bending stress is generated by moment or a flange force in the beam, either tension or compression, and is applied uniformly over the area of the tee. The secondary stress, or veirendeel stress, is caused by the transfer of shearing forces over the web opening. The resulting overall stress is the sum of the primary and secondary stresses. The tee section is then analyzed by traditional methods in accordance with AISC's ASD 9th edition or LRFD 2nd edition steel design codes.

Shear

The shear in a castellated beam has to be checked both vertically through the opening and horizontally through the web post. The vertical shear check is checked in the same manner that one would check shear in a WF beam. The horizontal shearing stress, more commonly called *vq/It* stress, has to be checked at incremental intervals vertically along the web post because of the variability of the cross section.

Web Post Buckling

The web post design procedure was developed by Drs. Dick Redwood and A. A. Aglan of McGill University in Montreal, Canada. Dr. Redwood has spent several years testing and developing design procedures for both castellated beams and beams with web openings. Their tests include both full scale destructive as well as finite element model tests on a full range of opening heights, opening widths, web post widths, and web thicknesses. Their published tables give the ultimate capacities of the full range of the previously mentioned variables. The published capacities are simply compared to the required resistance for the geometry of opening selected with a factor of safety or load factor applied.

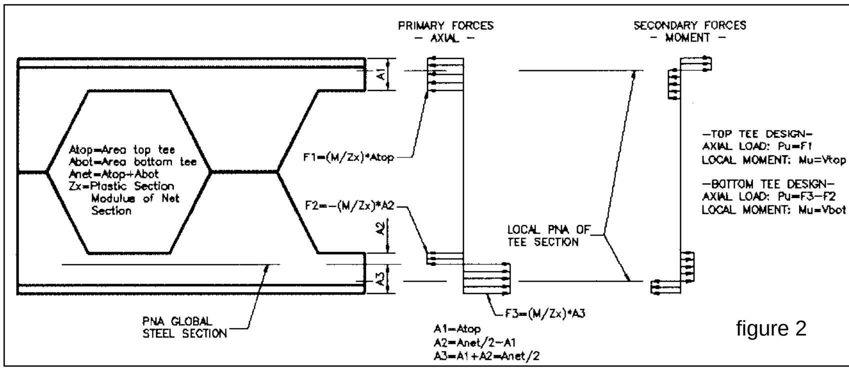

figure 2

Cost Effective Applications

Although there are numerous different applications for which a SmartBeam can be economically used, they all have common characteristics. These include composite application and longer than traditionally used spans. As a result of the deeper section, the SmartBeam has better long span capacities and vibration characteristics than other structural floor framing materials.

Office Buildings/Mezzanines

SmartBeams are ideally suited for long-span composite floor construction. Today owners are looking for more flexibility in space planning which leads to more column-free space. This economically gives them floor flexibility without the intrusion of interior columns. By incorporating the HVAC through the web openings, about 1'-0" of floor-to-floor height can be taken out of the height of the building compared to other long-span floor systems.

Parking Garages

With increasing real estate costs, developers have determined that it is more cost effective to buy less property and to maximize their space by using multi-level parking. SmartBeam parking decks have been constructed for as little as $4500 per space. This is a savings of approximately $1500 per space over a comparable pre-cast parking garage. For an average sized garage of 500 cars, this is a savings of $750,000 per garage. The long-span nature of parking garages lends these types of structures to the use of SmartBeams. This alternate gives owners a clear-span, column free parking area with the quality of a continuous slab floor deck and the efficiencies and cost competitiveness of a steel framed parking deck.

Summary and Conclusion

The castellated beam is a time proven composite structural floor-framing member that with the power of the computer and automated manufacturing equipment has become a more economical floor framing system. With SmartBeams excellent long-span capability, vibration characteristics and cost effectiveness it will become the long-span composite structural material of choice for floor construction.