9 Monorails

9.1 INTRODUCTION

The monorail crane is a common type of industrial crane which consists of a single beam with a hoist that can run along the beam. In the industries in which they are designed and used, monorail cranes are usually just called monorails. Generally the beams are doubly-symmetric I-beams and the trolley wheels run along the bottom flange as shown in Figure 9.1.

Monorails are often used in industrial buildings to provide a simple and economical method of transferring materials or equipment such as motors, pumps and valves to specific locations, mostly without the need for the operational flexibility and expense of an overhead gantry crane. The transfer is often from outside the building to inside and vice versa. Once inside the building, the item can be moved, if required, to any point within the building by an overhead crane. Some monorails have both curved and straight sections which allows more flexibility.

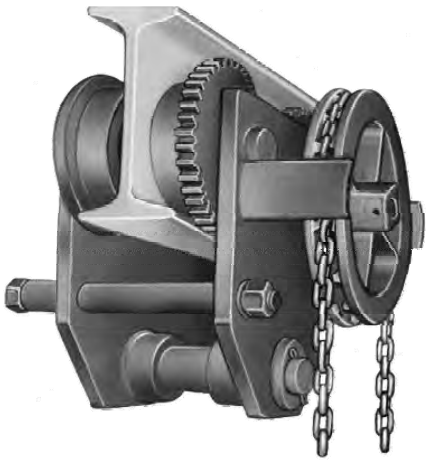

Photo courtesy Anker Max Cranes

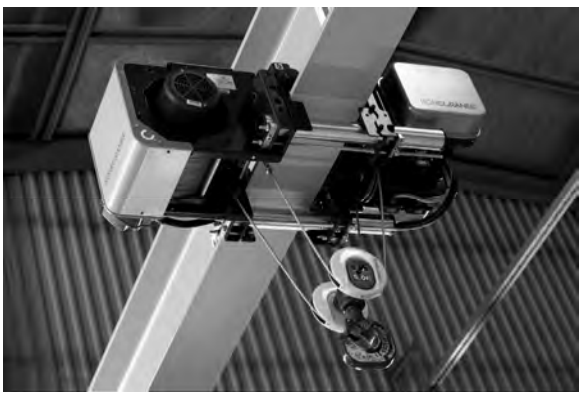

Photo courtesy Kone Cranes

Figure 9.1 *Monorail Cranes*

Monorails have a wide range of safe working load (SWL) from as low as 100 kg to in excess of 25 tonnes. Their operation ranges from fully manual using a simple manual chain hoist to fully electric with motors not only for hoisting, but also for travel along the beam. Most monorail trolleys for light loads have four wheels but those lifting heavier loads may have eight wheels.

It has been customary for the structural designers of monorail beams to assume that the wheel loads of four wheel trolleys are equal. However, with more recent trends in hoist design, two of the four wheels can carry more than 80% of the total with one wheel carrying more than 40%. This has serious implications for the assessment of flange thickness because the actual maximum wheel load can exceed the assumed wheel load by more than 60%.

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9.2 STRUCTURAL DESIGN

9.2.1 General

Monorail beams are subjected to gravity loads and to small horizontal loads due to inadvertent off-vertical lifting. The applied loads cause not only global but also local transverse and longitudinal bending of the bottom flange as well as lateral bending of the web. The local and global flange stresses are coincident when the hoisted load is between two supports but not when the hoisted load is at the end of a cantilever.

Where the hoist must pass an intermediate or cantilever support, a monorail beam is necessarily supported by its top flange and so there can be no lateral restraint to the bottom flange. Hence the cross section at such a support will not be fully twist restrained and this can influence the buckling moment. The loads are also applied at or below the bottom flange and this has a beneficial effect on beam buckling. Deflections also need to be limited to ensure safe and satisfactory operation and travel of the hoist.

The principal issues for structural design are:

- Flexural-torsional buckling and hence member capacity
- Local flange bending in combination with global bending
- Adequate web thickness to deal with lateral web bending
- Controlling vertical deflections
- Controlling lateral deflections

AS 1418.18 [1] groups crane runway beams and monorails together and provides a concise set of rules for monorail design which accounts for these issues. The code allows two methods of design – either permissible stress design to AS 3990 [2] or limit states design to AS 4100 [3]. Unless a specific requirement of the code takes precedence, the code's intention is that one method or the other is to be used exclusively. This book uses the *limit states design method* to AS 4100 except for the specific permissible stress requirements for flange and web thicknesses in AS 1418.18.

9.2.2 Loads

9.2.2.1 GENERAL

For the structural engineer, the determination of design loads for monorails is a different process from that for crane runway beams. In both cases for preliminary design, the designer generally needs to make assumptions about the type of crane or hoist and perhaps the manufacturer, and then make an allowance for the maximum loads. However, AS 1418 requires the crane manufacturer to provide the dynamically factored vertical and lateral wheel loads for *crane runway beams*, and a designer can extract these loads from catalogues or obtain them from a potential supplier. The code does not explicitly require the manufacturer

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including
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