11

LINTELS AND ARCHES

There are two ways to span openings in masonry walls. *Beams and lintels* are horizontal elements which carry loads as flexural members. Masonry *arches* may be flat or curved, but carry loads in compression because of the shape or orientation of the individual units.

Large wood or stone lintels were used in ancient Egypt and the Middle East to provide small window and door openings in massive loadbearing masonry walls. The strength of individual stones or timbers, however, limited the size of such openings. Early corbeled arches were constructed by progressively projecting the masonry units themselves across the top of an opening until they met at the apex, carrying the load essentially by cantilever action. True compressive arches were developed as early as 1400 B.C. in Babylonia and later perfected by the Romans, along with barrel vaults and domes. In more recent history, brick arches have been used for long spans with heavy loading, as in the railway bridge at Maidenhead, England, built in 1835, which spans 128 ft with a rise of 24.3 ft. A railway bridge constructed in Baltimore in 1895 spans 130 ft with a rise of 26 ft.

This chapter discusses the design of steel, concrete, and masonry lintels and masonry arches. Structural masonry beams for large openings or heavy loads are discussed in Chapter 12.

11.1 LINTELS

Lintels of steel, reinforced masonry, stone, concrete, precast concrete, and cast stone and wood are still used today to span small openings in masonry walls. Lintels must resist compressive, bending, and shear stresses (*see Fig. 11-1*). Lintels must be analyzed to determine the actual loads which must be carried and the resulting stresses which will be created in the member. Many of the cracks that appear over door and window openings result from excessive deflection of lintels which have been improperly or inadequately designed.

11.1.1 Load Determination

Regardless of the material used to form or fabricate a lintel, one of the most important aspects of design is the determination of applied loads. When

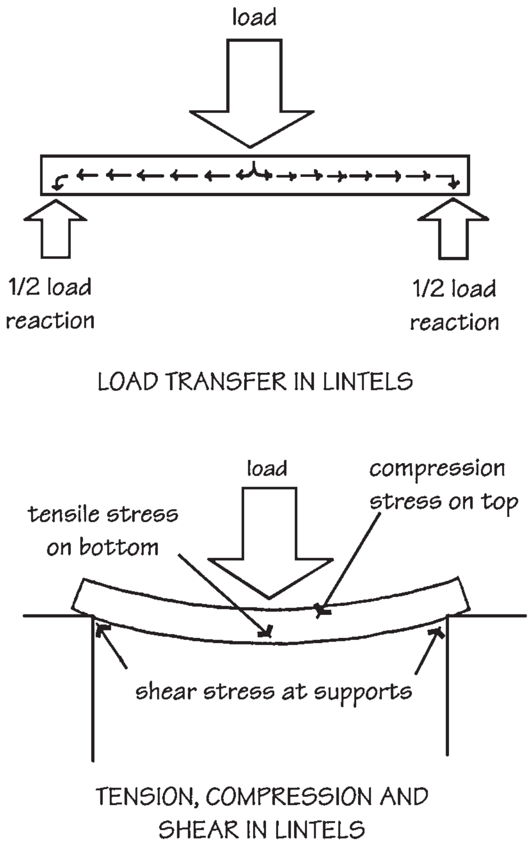

Figure 11-1 Lintels must resist compressive, bending, and shear stresses. (*From Beall and Jaffe,* Concrete and Masonry Databook, *McGraw-Hill, New York, 2003.*)

masonry is laid in a running bond pattern, it creates a natural corbeled arch which transfers much of the vertical load to either side of the opening (*see Fig. 11-2*). The area inside a triangle with sides at 45° angles to the lintel represents the masonry which must be supported by the lintel (*see Fig. 11-3*). Outside this area, the weight of the masonry is assumed to be carried to the supporting abutments by natural arching. For this assumption to be true, however, the arching action must be stabilized by a minimum of 8 to 16 inches of masonry above the top of the triangle. There must also be sufficient masonry mass on both sides of the opening to resist the horizontal thrust, and there cannot be a movement joint at either side of the opening. If arching action cannot be assumed to occur because of inadequate height above the load triangle, inadequate thrust resistance, movement joint locations, or because the masonry is not laid in running bond, the lintel must be sized to carry the full weight of the masonry above its entire length (*see Fig. 11-4*). When arching action is assumed, the lintel requires temporary support until the mortar has cured sufficiently to allow the masonry to assume its share of the load. *Figure 11-5* shows an elevation of an opening with a concrete plank floor and concrete beam bearing on the wall, and a graphic illustration of the distribution of these loads. The triangular area (*ABC*) immediately above the opening has sides at 45° angles to the base and represents the area of wall