BELL SYSTEM PRACTICES
Outside Plant Construction and Maintenance

SECTION G45.320.1
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AT&T Co Standard

CONCRETE AND MORTAR
INSPECTION INFORMATION
REINFORCED CONCRETE

1. GENERAL

1.01 Plain concrete and brick masonry can withstand little tension but have high resistance to compression. In comparatively shallow manholes constructed in firm soil most of the forces acting upon the walls are compression forces and therefore the walls are usually specified to be of plain concrete or brick. All manhole roofs and the walls of deeper manholes are subjected to both compression and tension forces and therefore the concrete must be reinforced with steel in order to provide the high resistance to tension which is lacking in plain concrete.

2. FORCES DEFINED

2.01 When various loads or pressures act upon a manhole wall or roof they are called external forces. A rule of mechanics is, "To every action or force there is an equal and opposite reaction." The opposite forces to the external forces acting upon the manhole wall or roof are within the wall or roof and act to resist motion or change of shape and are called internal forces. Thus, when the earth pushes against a manhole wall it exerts an action or active force and the wall presses against the earth with an equal and opposite internal force called a reaction.

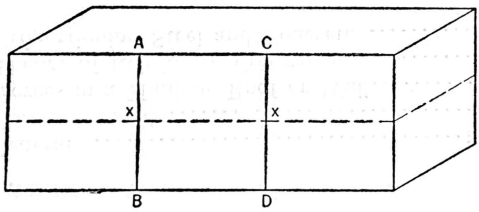
2.02 When two equal and opposite forces act in a direction away from each other on a body such as a rope, the body is in tension, because the tendency of the forces is to stretch or pull the rope apart.

2.03 If the forces act against a body such as a brick, in a direction towards each other, the body is in compression, because the tendency of the forces is to compress or crush the brick.

2.04 The forces exerted by the fibers of the rope to keep from being pulled apart or of the brick to keep from being crushed are called "internal stresses" or usually just "stresses."

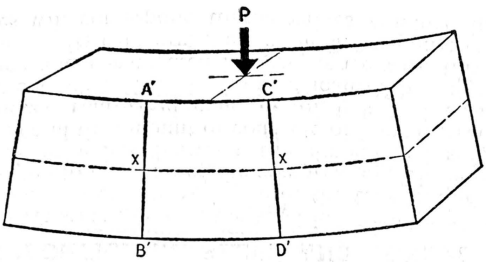
3. FORCES IN A MANHOLE ROOF OR WALL

3.01 When a truck passes over a manhole roof or when there is lateral earth pressure against a wall, the roof or wall tends to bend from the load. In order to resist this bending, both tension and compression stresses are set up within the roof or wall. As an example, the following illustration represents a section of a manhole roof without any load on it:



Two parallel lines, AB and CD are drawn on the edge of the section. The lines being parallel, the distance AC equals the distance BD. The dashed line is the center of the section.

3.02 A load, designated as P, is then applied to the roof and it tends to produce a bending of the section as shown in the following illustration:



This bending causes the lines AB and CD to rotate about the points XX to the positions A'B' and C'D'. The distance AC is shortened to A'C' or compressed and the distance BD is lengthened to B'D'.

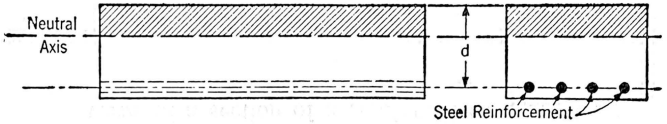
3.03 The internal fiber stresses in the roof offer resistance to this shortening and lengthening. The upper fibers are in compression and the lower fibers in tension.

3.04 Since concrete has a high resistance to compression but can withstand little tension, steel is placed close to the bottom of the roof slab and is expected to resist all the tension. Thus the concrete and the steel operate together in the roof. The combination of the two materials constitutes reinforced concrete.

4. THEORY OF REINFORCED CONCRETE

4.01 Referring again to the illustrations in Part 3, it will be noted that the lines AB and CD were rotated about the points XX located on the section's center line which is called the neutral axis. Therefore, only those fibers above the center line were shortened and are in compression and only those fibers below the center line were lengthened and are in tension. In addition, the fibers at the extreme top of the section are shorter than those just above the center line and are therefore in greater compression and the fibers at the extreme bottom of the section are longer than the fibers just below the center line and are therefore in greater tension.

4.02 The following illustrations represent the side and end views of a section of a reinforced concrete roof:



The shaded area represents the compression side of the concrete slab. The steel reinforcement on the tension side is expected to resist all of the tension and is placed as close as practicable to the bottom of the slab where the greatest tension occurs. The concrete on the tension side of the neutral axis merely holds the steel in place and prevents corrosion. Since the two materials, steel and concrete, have different strength characteristics the neutral axis does not coincide with the center line of the slab but is located about 3/8 of the distance "d" below the top of the slab. The distance "d" extends from the top or compression side of the slab to the center line of the steel reinforcement and represents the effective thickness of the concrete. The concrete below the reinforcement does not contribute to the structural strength of the slab.

4.03 In accordance with these fundamental facts, the practices provide that all main reinforcement be placed one inch from the inner surface of all reinforced roofs, walls, and floors. If the construction plans specify that a 7-inch roof be placed on a manhole, and, by mistake, the reinforcing rods are placed 3 inches from the form instead of 1 inch, then the roof is no stronger than a 5-inch roof. This points to the importance of seeing that reinforcing is placed, with respect to the thickness of the concrete, as close as practicable to the position specified for that particular section. As reinforced floors are designed to resist pressure from below, the main reinforcing is placed near the top of the slab, and care should be exercised to see that it is not displaced downward by trampling.

5. PROPORTIONING STEEL AND CONCRETE

5.01 As stated before, the steel in a reinforced concrete slab is expected to resist all of the tension and the concrete is expected to resist all of the compression. Therefore, a definite relationship exists between the amount of steel of known strength and the amount of concrete of known strength required to produce reinforced concrete of balanced design which is strong enough to sustain a given load. When a concrete slab, designed and constructed in accordance with this relationship, is loaded to its capacity, the maximum tension and compression stresses will correspond to the values assumed in the design.

If the area of concrete should be reduced, the concrete would reach its allowable stress first and fail before there would be failure of the steel. If the area of the steel should be reduced, the steel would reach its allowable stress first and fail before the concrete. Failure in either material would result in failure of the slab.

5.02 Referring again to the illustration in Paragraph 4.02, it is apparent that considerably less than one-half of the concrete in a reinforced slab resists all of the compression. The compression stresses occur near the outside surfaces of manhole walls, floors and roofs and, therefore, it is very important that these outside surfaces be free of any major indentations that would reduce the effective thickness of the concrete under compression and thereby lower the strength of the slab.

5.03 Inexperienced workmen sometimes have a tendency to over-reinforce a slab with the expectation that the strength of the slab will be materially increased. Such a situation might occur where lack of space in the street prevents a manhole wall of the proper thickness to be constructed. Manhole walls are not always designed with strict relation to the lateral load requirements because of other considerations. For that and other reasons, additional reinforcement may have value in some cases. Determining the quantity, shape and location of the additional steel, however, requires computations not always practicable to make in the field. Usually, the increase in strength gained from placing additional reinforcement is small in proportion to the extra steel used, and therefore the practice is one to be avoided.