While E-60 bridges are stronger than those of E-50 class, it is probable that if the weights of engines ever increase to an extent sufficient to develop their capacity, many of these bridges, as now being constructed, will not have sufficient clearance to enable such excessively large locomotives to be safely operated. If, therefore, E-60 bridges are constructed, it would be well to provide a lateral clearance of at least 8 ft. from the centre of the track and an overhead clearance of not less than 25 ft. above top of rail, in which case there will be some possibility of operating over them the excessively large locomotives required to develop their strength.

Those roads which prefer stronger bridges on account of severe and heavy service on high grades could reasonably adopt the E-60 as standard for high-grade divisions and E-50 for low-grade divisions.

### CONCLUSIONS.

Conclusions, as they appear to the writer, consistent with the foregoing investigation may be briefly summarized as follows:—

(1) It is reasonable to assume that rolling loads of sufficient weight to develop the full regular service capacity of an E-50 bridge, as indicated in Table 5, will probably be operated regularly over heavy-grade divisions, but it is doubtful whether such types will ever be regularly operated over low-grade divisions.

(2) It is less reasonable to assume that rolling loads of the weights necessary for developing full service capacity of an E-60 bridge, as indicated in Table 6, will ever be operated even on high-grade divisions, unless present standards of gauge, roadbed and clearances are abandoned and the road practically reconstructed.

(3) An E-50 American Railway Engineering Association Specification bridge is a good and economical type with sufficient strength to safely carry, in regular unrestricted service, the heaviest locomotives that can be safely operated without a possible complete revision of present standard clearances.

(4) An E-60 bridge is heavier, stronger and stiffer than an E-50 bridge and its construction will cost from 12 per cent. to 15 per cent. more. It will safely carry the heaviest loads that it is possible to conceive of, but if the weight of engines ever increases sufficiently to develop its capacity, bridges as now constructed will probably not give sufficient clearance to enable such enormous locomotives to be safely operated.

(5) The tendency of railways is toward the adoption of E-60 bridges, but this in many cases appears to be influenced more by precedent than by good, sound reason and judgment, and it is stimulated by those who profit thereby on account of the greater tonnage of metal used in construction.

(6) If an E-60 bridge is considered warranted by the heaviest power likely to be operated, its proper place is on high-grade divisions, and it would, therefore, be good engineering practice to construct E-50 bridges on low-grade divisions, since they will have sufficient strength to permit the occasional operation to and from high-grade territories of the heaviest equipment which could be operated on the E-60 bridge in regular service traffic.

(7) E-60 bridges would be more consistent if constructed with greater clear width and height than sanctioned by present standards, because this would provide for probable increased width and height, as well as weight, of the enormous rolling stock required to develop their capacity.

## VITRIFIED BRICK PAVEMENTS.*

By Will P. Blair.

The extent of injury done to brick street pavements from contraction and expansion has been greatly magnified on the one hand, and the difficulties in preventing any injury at all have been enlarged upon to an exasperating degree. We freely grant that there are behaviors in structural materials, particularly of cement, brick and iron, that are not fully and completely understood, in spite of the research work that has been done by various investigators. But that is no argument at all against the use, within the range of what we do know and even beyond that which we know, even if we should encounter hazardous and strange phenomena. In fact, if we are to await a perfect knowledge and information concerning all utilitarian matters but little progress would be made and we would be without the enjoyment of many useful and pleasurable things in life.

The city of Cleveland has afforded a field of study during the past season much beyond that of any locality in the country. The season has been very changeable in temperature. Sometimes a variation has occurred of more than 40 degrees within a period of one week, but in the experience of many years preceding the temperature has not been subject to such great variations. While it is entirely fair to say that 75 per cent. of the streets of Cleveland are properly cement filled, provision for expansion and contraction has not been considered of very great importance, and to a very large extent has been neglected. Even with the streets built under contracts calling for expansion cushions, very few streets are found where the provision exists. In spite, however, of the almost entire lack of provision for expansion and contraction, out of more than 2,700 street intersections, but 27 ruptures occurred. Twelve of these were examined personally by the writer, and in every case no provision for expansion relief whatever was found. In the remaining, I was assured by Mr. Abbott, the engineer in charge of repairs in that city, the same lack was in evidence. Throughout the city quite a few cracks occurred away from intersections, but these are not really serious to the utility of the pavement because it very seldom occurs that rutting follows; at the worst, no greater injury follows than that which occurs to each individual brick where soft fillers are used. In no case, however, have they occurred where expansion cushions have been provided.

There occurred a rupture at the intersection of Decker avenue and East Eightieth street, neither of which had any provision at all for expansion relief along the curb or transversely. The expansion force necessarily found relief at the intersection. You may ask, why at the intersection? Simply because it was the only place that the concentration of the forces found in the four streets could concentrate. The force of expansion concentrated at the intersection square, in comparison with that directed against any other portion, was the greater and so the resistance was weak and could but yield to the strain. Any other part of either street could be approached by the force of expansion concentrating from but two directions, but in the intersection the force was fourfold. The compressive resistance was no more than in a single street, so that a rupture followed. Observing gentlemen in the neighborhood informed me that it raised five feet at the intersection. A nine-year-old boy with mental equipment for accuracy informed me that the men did not know

*Paper before the American Society of Municipal Improvements.