RECENT PRACTICAL DEVELOPMENTS IN THE DESIGN AND CONSTRUCTION OF BRICK PAVEMENTS

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Brick pavements have been laid on various types of base courses, both flexible and rigid. In the southern section of the country especially, brick surface courses have been very successful on such foundations as natural sand, Florida lime rock, crushed slag, crushed stone, chert, and gravel. In the northern parts of the country, brick pavements have given satisfactory service on water-bound and bituminous macadam base courses, well-drained gravel, and, in a few instances, on hot mixed "black base." In the steel manufacturing districts there are a number of installations on compacted, granulated (water-cooled) blast furnace slag bases.

Concrete is the material now in most general use as the foundation course. In most instances, plain concrete has been used, although in several localities, steel reinforcing is included. There is some difference of opinion among engineers as to whether a concrete of relatively rich or lean cement content should be used. Some favor a lean mix and greater slab thickness, the argument in favor being that the tensile strength is less and that, although the cracks which form will be more numerous, they will be finer, which will not permit the filtering in of cushion material. Many engineers, in the case of bad subgrade conditions, favor a richer concrete mix for the base course and the use of reinforcing. The rich base is favored more in the north where weather conditions may damage a lean mix. The trend seems to be to use richer concrete for base courses on state highway construction than in municipal work. This is probably due to the fact that in municipalities there is more thorough drainage and satisfactory subgrade conditions.

Surface unevenness caused by cushion material filtering into base cracks has recently brought about considerable sentiment in favor of designing concrete bases with transverse and longitudinal joints providing for contraction and expansion. The contraction joints are usually of the weakened plane type filled with bituminous material and covered with a strip of burlap; the expansion joints are of the open type sealed at the bottom with bituminous material and covered with a strip of light gauge metal. This design provides for crack control as well as stresses in the slab, a matter which has been generally neglected in concrete base design. Bases of this type have been constructed recently in Summit and Stark Counties, Ohio, Niagara County, New York, and several other places with very satisfactory results.

It is customary to use a concrete base course thinner under a vitrified brick top course than for a single concrete pave-
ment slab. The thickness and strength should always be suf-
ficient to meet conditions safely. It is false economy to at-
tempt to save money by placing a high-class top on an in-
adequately designed base.

The smoothness requirements for surface finish of base
courses of all kinds in modern specifications are practically
the same as for the surface of a pavement; \( \frac{1}{4}'' \) in ten feet is
a common specification. Finishing machines are now gen-
erally required.

BEDDING COURSE (CUSHION)

When it was the practice to construct base courses with
an irregular and rough finish, the bedding course was used to
take out the inequalities and provide a smooth surface on
which to lay the brick. There was always considerable vari-
ation in depth, which often resulted in a shifting of the cushion
with subsequent effect on the brick surface course. Where
bituminous fillers were used, there was also a possibility that
heavy trucks would in the course of time disturb the surface
where the cushion was deep. A present-day brick pavement
is designed with a much thinner cushion course of uniform
thickness. This is possible because modern specifications re-
quire the base course to be finished practically as smooth as
the surface of the road. The bedding course should not be
thicker than one inch and, preferably, \( \frac{3}{4} \) of an inch.

The material which has been most frequently used is sand
with a certain amount of loam permitted. In the old grout-
filled pavements the defects, due to cracks in the base and
the shifting and settling of the bed, did not show up to any
extent because the brick were bonded into a slab which bridged
over such places. The bituminous filler, which takes care of
expansion and has eliminated the unsightly cracks which de-
velop in grout-filled surfaces, has brought with it some of the
defects above mentioned. In order to eliminate these faults
it is now generally admitted that crack-controlled, smooth
bases are essential with all cushion materials and especially
with sand. Many engineers are now opposed to the use of
sand as it seems to be safe only so long as it remains in a
damp condition.

Cement-sand, another bedding material, while it forms a
bed which will not shift or flow into cracks, is not entirely
satisfactory because it becomes too rigid and is more or less
of an anvil with traffic acting as the hammer.

Granulated (water-cooled) slag, in localities where it can
be secured economically, is ideal. It is highly compactable
and has certain cementing qualities that in time will form a
bed which will remain in place but will not develop the metallic
hardness of sand cement. It can be rolled with a power roller
and is especially adapted to resurfacing where the depth of the
bed is variable. Granulated slag retains a certain amount
of moisture for some time after coming from the plant, but it should be sprinkled on becoming dry to insure compaction and cementing action.

Fine stone and slag screenings have been used successfully as they have cementing qualities which will bond them together; this material should also be sprinkled before rolling to insure compaction and cementing action.

A development of recent years is the use of a sand mastic mixture for the bedding course. This type of cushion is required in the latest specifications of the Illinois Highway Department and has been used on the brick resurfacing projects constructed this year in that state. Other recent projects on which bituminous mastic cushions have been used are in Olean and Auburn, N. Y. It was also used in Mattoon, Illinois, in 1923 and 1924 in the proportions of 96 per cent sand and 4 per cent by weight of light refined tar. A recent examination showed these pavements to be in excellent condition. Samples of the cushion were taken from the pavement and subjected to laboratory tests. A visual examination showed the material to have the appearance of dark brown to black sand, well compacted but not cemented, and it was decidedly damp. The laboratory extraction tests showed that only about 1.16 per cent of the original 4 per cent of tar remained. Both tar and asphalt cutbacks as well as straight oil asphalt have been used in making mastic cushion. On the Illinois work, 6 to 7 per cent of bituminous material by volume seemed to give best results. The mastic was mixed in paving mixers and in some cases in an asphalt plant. Best results due, probably, to better drying facilities were obtained in the asphalt plant. Difficulty was encountered in some cases in properly rolling the material, which probably was due to the mixing being done too far ahead of actual use, this having permitted some of the volatile solvents to evaporate.

The striking off and preparing of a uniform bed is of extreme importance in the laying and maintaining of a smooth brick surface. It would be well if specifications should prescribe definitely the type of screed or templet which should be used; it is just as important as certain other types of equipment which are definitely specified. Such a screed should be designed so as to be substantial, and the screed board itself should be mounted on carriers ten feet long which should be equipped with rollers operating on the curbs. In case of a wide pavement the screed could be half-width and disc wheels could be used on the one end which would roll on the concrete base, provided it was smooth; otherwise the rollers could be used over flat wood or metal forms lined up uniformly. Such a screed should be of all-metal construction with the exception of the board itself, which could be shod with an angle iron. The use of a long straight-edge on the finished cushion
and the correcting of all unevenness in the bedding course before laying the brick has been found to be very helpful.

**BRICK COURSE**

The depth of the brick course in modern design is less than was formerly used. Until comparatively recent years the minimum depth of the brick course was 4" and the brick were laid with their longer cross sectional dimension vertical (on edge). Experiments conducted by the U. S. Bureau of Public Roads on a brick paved circular track at Arlington demonstrated that, when properly supported, brick down to 21/2" in depth will withstand heavy traffic. The depth of vitrified brick surface course in most common use is 3". The brick are now laid with the shortest dimension vertical (flatwise). This has served to secure a more satisfactory riding surface and, because of a less number of brick units required and fewer joints to fill, with decreased depth, has resulted in lowering the cost of brick pavements.

The initial simplification project of the U. S. Department of Commerce, in its effort to eliminate waste in industry, was inaugurated by the producers of paving brick in 1921. As a result of the work of the Permanent Committee on Simplification of Variety and Standards for Vitrified Brick, on which the leading engineering organizations are represented, the Department of Commerce has recognized the following types and sizes:

- *Plain wire-cut brick (vertical fiber lugless)*
  - 21/2 x 4 x 81/2 inches
  - 3 x 4 x 81/2 inches
  - 31/2 x 4 x 81/2 inches
- *Repressed lug brick*
  - 4 x 31/2 x 81/2 inches
- *Wire-cut lug brick (Dunn)*
  - 4 x 31/2 x 81/2 inches
  - 3 x 31/2 x 81/2 inches

The trend is toward the increased use of a lug type of brick which will insure positive separation of the joints and permit more thorough penetration of the filler. The lug brick has always been used more extensively in the East and, according to recent reports, will be required in certain sections of the West where lugless brick has heretofore been used. A type of lug brick introduced recently that is meeting with much favor is what is known as the wire-cut brick (vertical fiber) with lugs. This differs from the wire-cut lug brick in that the wire-cut (instead of the die) side is in the surface. Difficulties in manufacturing this type of brick have been overcome and the wire-cut surface provides an additional non-skid feature. If this type of brick proves satisfactory, it would be possible to standardize on this type, which would
result in further simplification of varieties. This would con-
template a standard brick with the same surface dimensions,
the only variation being in the depth. It has been suggested
that three depths—2 1/2", 3", 3 1/2", or 4"—would answer all
purposes. It will take several years before it will be known
whether such a development will be the result of the intro-
duction of the wire-cut brick with lugs.

The workmanship in laying brick pavements has been im-
proved materially through requirements of the modern brick
paving specifications. The Illinois and the Pennsylvania high-
way departments' specifications require a smoothness of \( \frac{1}{8}'' \)
in ten feet. There is no reason why the brick pavement should
not be made as smooth as any other type, as the surface con-
tour can be readily adjusted during construction and later,
after the pavement is under traffic.

**FILLER**

The filler now being used in practically all brick paving
construction is a bituminous material—in a great majority
of the cases, straight asphalt. Portland cement grout, which
was formerly used as a filler on all high-grade construction, is
still required to some extent for special work, such as street-
car tracks, gutters, and parking strips. In such cases, pro-
vision is usually made for expansion. The reason that a bi-
tuminous or flexible material has been almost universally
adopted for filler is because difficulties incident to temperature
changes, such as internal stresses, occasional "blow-ups," and
unsightly surface cracks have been obviated by its use. In
addition, if properly constructed, the joints are sealed against
the entrance of moisture and the edges of the brick protected.

The grief encountered on account of unsatisfactory fillers
has called for considerable study during the past two years.
The most serious trouble has been bleeding of the filler during
hot weather and slipperiness caused by some of the filler re-
mainning on the surface for a time after application.

Some reference has been made to the coating of the sur-
face with certain materials which would prevent the adhesion
of the filler. This has proved to be effective, but great care
should be taken that none of the material creeps down along
the sides of the brick and prevents adhesion where it is needed.
The use of coarse grit (not sand) rolled into the surface im-
mediately after application has been found to be of consider-
able value in preventing slipperiness and it also peels off the
surface in a better manner. The tendency seems to be in
favor of a harder filler; the soft fillers which have been used
during recent years were to some extent the result of neces-
sity brought about by the use of a lugless brick, which has
now been largely discontinued. The harder fillers seem to
hold their place satisfactorily; they do not soften enough to
cause any trouble and they become so brittle during cold
weather that the excess soon chips off the surface.
A mastic asphaltic mixture, consisting of about 25 per cent of sand or fine mineral aggregate, has been used successfully in the cities of New Orleans, La., and Jacksonville, Fla. The aggregate content, of course, increases the stability of the filler and decreases its tendency to bleed or flow at high temperatures. It should be noted that both of these cities are located in the far south. Trinidad Lake asphalt, which contains from 25 per cent to 35 per cent of mineral was used this year in Richmond, Va., on a small area. According to reports the results were very good.

Even with an ideal filler the results will be unsatisfactory if there is poor workmanship in its application. The asphalt filler should be heated sufficiently to insure full penetration of the joints without passing the danger point, and a thermometer should be required on the heating kettle or tank. It should be forced into the joints as soon as possible after it is applied to the surface of the brick. Asphalt that has cooled will congeal, allowing only partial penetration into the joints which should be completely filled. In addition to this, cool asphalt will spread out over the surface, causing a rough pavement and slippery conditions. An application device that has come into use in recent years has greatly improved the application of asphalt filler. It is known as the wheeled squeegee (or buggy) and consists of a small tank mounted on wheels, with a discharge pipe and curved flexible squeegee attached. The asphalt is discharged direct from the heating tank into the squeegee bucket and its flow on to the pavement is controlled with a valve by the operator. It cools very slowly in the small tank and is raked into the joints immediately after it flows out on to the brick. A number of recent specifications require this method of application. Another recent development is the use of truck distributors in transporting the filler from the railroad tank cars to the site of the construction. On some projects the asphalt has been applied under pressure direct from the truck distributor and scraped into the joints with hand squeegees. The use of the truck distributor insures that the filler is maintained at the required temperature. In many cases, because the application of filler is about the last operation in connection with the construction of a brick pavement, the work is performed during cold weather. This has frequently been the reason for poor results. Modern specifications require that when the temperature of the brick is below 50° F. it be raised to not less than 80° F. immediately before applying the filler, by the use of surface heaters or similar devices. This method is not expensive and will insure satisfactory results.

Modern specifications also specify a minimum thickness of the surplus asphalt remaining on top of the brick. This is usually limited to 1-32 of an inch. Another method that has been used to a limited extent, is to coat the surface of the
brick with a material that will facilitate the removal of the surplus asphalt after the application. Materials that have been used and proposed for this purpose are ordinary white-wash, light oil, and sodium silicate.

RELAYING, REPLACEMENT, AND RESURFACING

Vitrified paving brick that have been in use for as long a period as thirty years are being taken up and relaid. Frequently, the old brick are relaid on the existing foundation after it has been repaired and reinforced. In other cases, the brick have been relaid in another location. As most paving brick were originally laid on edge, there is frequently a 100 per cent recovery, when relaid in the modern manner. Among the cities where salvaged brick have been relaid in 1931 and are beginning a new period of service, are Pittsburgh, Pa., Albany, Ga., Ashtabula, Alliance, Mt. Gilead, Uhrichsville, and Zanesville, Ohio. Pavements that have been constructed of brick reclaimed from old pavements have the appearance of new pavements and are striking illustrations of the long life and salvage value of a properly manufactured vitrified paving brick.

One of the most important uses which is being made of paving brick is that of resurfacing old pavements which are beginning to show signs of weakness and deterioration. This resurfacing is usually performed in conjunction with the widening of the old pavement. If the widening is slight (from 2 to 4 feet), it is usually done by constructing header curbs equivalent to the extra width and resurfacing the old pavement. If the widening is sufficient to warrant the construction of any base, the edge of such new base should be anchored under the edge of the old pavement. Careful inspection of the condition and value of the old pavement should be made and all sections which are doubtful should be reconstructed. It is considered to be better practice to resurface an old pavement before it has gone beyond the danger point of salvaging, rather than to wait until it has deteriorated to such an extent that there is serious doubt as to its value as a base. Examples of brick resurfacing are in Newburgh, N. Y., Springfield, Ohio, Bloomington, Ill., Davenport, Iowa, St. Paul and Minneapolis, Minn., Summit and Stark counties, Ohio, and on the State Highway System of Illinois.

The use of brick of contrasting colors to mark traffic lanes, parking strips, and outlining directional and warning signs has appealed to some paving authorities and traffic officials. This kind of marking does not become obliterated and require renewal. The new bridge over the Maumee River at Napoleon, Ohio, completed in 1930, has the word "Napoleon" and a north point boldly outlined on the brick pavement in a light colored brick against the darker colored brick background. The purpose of this marker is to act as a guide to air travel.