GRAVEL ROAD TYPES

Surfaced Roads in the United States.

BEST SELECTION OF GRAVEL

Quality of Material Is Next in Importance to Proper Drainage-Clay Is Poorest Cementing Material We Have.

(Prepared by the United States Depart-ment of Agriculture.)

Roads that are artificially surfaced with gravel, or with earthy material in the composition of which gravel predominates, are called gravel roads. This designation covers a variation in type which ranges from roads surfaced with a natural sand-clay mixture containing a considerable percentage of gravel to those having so-called "gravel macadam" surfaces, composed almost wholly of pebbles and constructed in practically the same manner as first-class macadam roads. Gravel roads constitute about one-third-the total mileage of surfaced roads in the United States and are confined to no especial section of the country.

In the following discussion of gravel roads it is convenient to consider the ple, the so-called "blue gravel" which subject under the two general heads, "Selection of Gravel" and "Construction Methods."

Selection of Gravel.

Ordinarily the selection of gravel for use in road surfacing must be confined to local materials which are or can be made suitable for that purpose. Because of high freight costs it seldom happens that road gravel of even the very best quality is transported by rail a greater distance than about 100 miles from the source of supply, and in the vast majority of cases it is hauled directly from pit to road in wagons. Since the quality of gravel varies to a considerable extent, sometimes in different parts of the same pit, it is essential that local road officials, who frequently are charged with the selection of such material, should have some knowledge of the relation between the physical characteristics of gravel and its wearing qualities when placed in a road surface. While such knowledge can best be gained by actual experience with different kinds of gravel, there are certain general requirements which may be stated for the guidance of the inexperienced. For example, the following excerpt from Bulletin No. 2 of the Michigan state highway department presents in very concise form the characteristics which gravel for road surfacing should possess, in the judgment of the state highway commissioner, in order to meet the Michigan conditions.

Next to proper drainage, the most important thing in building gravel roads is to secure a good quality of gravel. Authorities have differed as gravels, most of them, in my opinion, placing too much stress on the immediate packing qualities. Indeed, the average township commissioner and farmers generally have become so imbued with the idea that it is necessary to use a gravel that will pack quickly that they have almost lost sight of the fact that the only thing which makes a gravel road better than an earth road is the pebbles, real stones, that it contains and is dependent upon to bear up traffic and resist wear.

Gravels that come from the pit with the pebbles cemented together, even though they contain no clay, will recement in the road and become harder than they were in the pit. Tests of specimens of this kind always show that there is much lime present and usually some iron, both of which are excellent cementing materials. Briefly, the experience of the state highway department warrants the statement that there are few, if any, bank gravels in Michigan that do not contain enough limestone and other soft pebbles which grind up under traffic to furnish sufficient binder to cause them to consolidate in a few months' time, if separated from the surplus sand and earth, and properly treated after applying to the road.

In accordance with these sugges tions, gravels are considered valuable for road purposes in the following

1. Almost in direct proportion to the percentage of pebbles constituting the

2. In direct proportion to the value as road metal of the rock fragments constituting the pebbles.

3. In direct proportion to the value as a cementing material under all conditions of weather, of the finer particles of earthy matter constituting

the aller or binder. In general, the physical characteristics of gravel which determine its suitability for use in surfacing a road

(1) The durability of the pebbles or rock fragments, (2) the quality of the binder, (3) the grading of the pebbles, The percentages given above usually and (4) the proportion in which the binder material is present. While the influence each of these factors should exert in fixing the selection of gravel for a particular road depends upon local conditions and necessarily is a question for individual judgment to decide, nevertheless a few points in connection with each factor that may aid materially in reaching a decision will be summarized in the following paragraphs.

Durability of Pebbles. The principal qualities which determine the durability of pebbles or strable in making the test.

stone of any kind when placed in a road surface are hardness, toughness, and resistance to wear. The extent to which pebbles possess these qualities depends very largely on the char-Constitute About One-Third of acter of the parent stone from which they were originally produced and accordingly varies over a wide range. Since nearly all gravel deposits contain pebbles which have been formed from many different kinds of stone, it has not been considered practicable to apply the ordinary laboratory tests for determining hardness, toughness, and per cent of wear to gravel, and the matter of comparing these qualities, as possessed by the pebbles from different gravel deposits, usually depends on visual inspection. Not infrequently a very casual inspection will reveal which deposit, among a great number, contains the largest percentage of hard, durable pebbles. There are comparatively few cases where this point cannot be determined with sufficient accuracy by sorting out the pebbles contained in representative samples from the different deposits, testing the various kinds with a hand hammer, and determining the relative proportions in which the more durable materials are present in the sample by means of a weighing device.

Ordinarily the most durable pebbles which occur in gravel deposits are those composed of either quartzite or chert, though many deposits contain fragments of limestone or trap rock, either of which may make an excellent road-surfacing material. For examoccurs in certain sections of the country usually is composed largely of trap-rock fragments and generally ranks high as a road material. While limestone pebbles usually are less resistant to wear than those of trap rock, they possess the advantage of a relatively high cementing value and their presence in gravel may aid greatly in securing a well-bonded surface without an excess of clay.

The Binder. No matter how durable may be the pebbles contained in a given gravel deposit, they cannot be used successfully in a road surface unless they can be well bonded together so as to present a combined resistance to the disturbing action of traffic. To accomplish this bond requires that the gravel contain some cementing or binding agent such as iron oxide, carbonate of lime, or clay. As already explained, certain pebbles, such as those composed of limestone, possess the property of becoming firmly bonded together by virtue of their own cementing

value. The principal cementing agent, or binder, present in most gravel deposits is clay, and in case of deposits which do not carry sufficient binder, clay usually is the material added to correct the deficiency. While there are many exceptions to this rule, it is sufficiently general to warrant treating as special cases those deposits in which the binder is not clay.

The suitability of clay for use as a binder for a gravel road surface depends on exactly the same characteristics as its suitability for use in sandclay construction. That is, a quality of clay which could be used satisfactorily in a sand-clay surface also should make a satisfactory binder for a gravel surface, provided it is used in proper proportion and is properly

mixed with sand. Grading and Proportions.

For gravel to make a satisfactory road surface, the stone particles should be graded in size so that the amount of binder required will be reduced to a minimum. The reason for this is that the binder usually is much less resistant to wear than the stone particles, and therefore it is desirable that the latter form as large a part of the wearing surface as is practicable. Most gravel deposits as they occur in nature satisfy this requirement in so far as grading of the pebbles is concerned, but they nearly always contain pebbles of a size larger than it is desirable to incorporate in a road surface. Natural deposits also not infrequently contain too large a proportion of sand or clay to produce satisfactory results. It is desirable, therefore, that specifications covering gravel for use in road construction should limit the proportions in which the fine and coarse materials shall be present and a maximum limiting size for the pebbles, as well as definite requirements regarding the quality of the pebbles and of the binder.

In general, it has been found that satisfactory gravel will conform the following limits as to percentages of fine and coarse material:

1. Material retained on a 14-inch sieve, 55 to 75 per cent. 2. Material retained on a %-inch sieve, not less than 15 per cent.

3. Material (clay) passing a 200mesh sieve for the surface course, 8 to 15 per cent.

4. Material (clay) passing a 200mesh sieve for the foundation course, 10 to 15 per cent.

The sand should be at least twice as great as the clay content; and the sand and clay, when thoroughly mixed, should be sufficient to fill the voids between the larger gravel particles.

will conform with this requirement. A satisfactory mechanical analysis of a gravel sample along the lines indicated above frequently may be made in the field by first separating the coarse material from the fine by means of a 14-inch mesh screen and then washing the clay out of the fine material, as described in the discussion of sand-clay roads. Both the coarse and fine materials obtained from the sample may be further separated into different sizes by means of suitable screens if, for any reason, this is de-

INTERNATIONAL

By REV. P. B. FITZWATER, D. D., Teacher of English Bible in the Moody Bible Institute of Chicago.) (Copyright, 1217, Western Newspaper Union.)

LESSON FOR SEPTEMBER 16

THE FIERY FURNACE.

LESSON TEXT-Daniel 3. GOLDEN TEXT-When thou walkest through the fire, thou shalt not be burned; neither shalt the flame kindle upon thee.-Issiah 43:2.

I. The Occasion (vv. 1-7). The fact that God said to Nebuchadnezzar, "Thou art this head of gold" (2:38) was too much for him. Though he appeared to have been deeply impressed with Daniel's God, his pride got the better of him. As he grew great and became conscious of it, he grew proud. This moved him to set up a colossal idol of gold in the Plain of Dura to be worshiped by all the people of his realm. It was an attempt at self-deification. It combined with it a political move, the object of which was to weld together the various kingdoms and peoples into one homogeneous body. He inaugurated a religious festival, and called upon all the people to worship the image which he set up. He backed this demand by civil authority. The penalty for refusal to bow down and worship the image was to be cast into the burning flery furnace. Imposing images are set up in many places, and men and women are being called upon to bow down and worship them. Some of these images are money, fashion, scholarship, worldly ambition, pleasures, etc., and woe be to those who will not worship before them.

II. The Behavior of the Hebrews (vv. 8-18). (1) the accusation by the envious spies (vv. 8-12).

Daniel's three friends had been promoted to positions of honor and responsibility. Certain Chaldeans whose envy had been excited by the promotion of these Hebrews, sought occasion against them. This they found when the Hebrews would not bow down to and worship the image. Envious eyes are always watching God's faithful ones. Had these Chaldeans been faithfully worshiping, they would not have seen the Hebrews.

(2) The king's rage (vv. 13-15). He calls the Hebrews before him. questions them and gives them another chance. The offense was not serious -they were defying the authority of the one who had honored them in their promotion; it savored of ingratitude. After closely questioning them he gave them another opportunity to consider their position before consigning them to the fire. His supreme mistake was in the challenge he made to the God of the Hebrews. He seems to have forgotten entirely the confession he had made with reference to God (2:47).

(3) The courageous reply of the faithful Hebrews (vv. 16-18).

They replied without passion or fear. The peace of God filled their hearts. Their behavior is an expression of triumphant faith. "We are not careful to answer thee in this matter. If it be so, our God whom we serve is able to deliver us from the burning flery furnace, and he will deliver us out of thine hand. O king. But if not, be it known unto thee, O king, that we will not serve thy gods, nor worship the golden image which thou hast set up." They coungeously showed their contempt for death. They were not afraid to die, but were afraid to sin against God. They knew that to bow down before this image was to disobey and dishonor God. While they did not know what God would do, in the premises they knew that he would do the right thing. These Hebrews were far away from home, exposed to the most severe temptation, but they saw their duty clearly set before them. God's law plainly settled it for them. They did not try to find an excuse to evade their duty, and seeing the way clearly they acted accordingly.

III. The Giorious Issue (vv. 19-30). (1) The harmless furnace (vv. 19-25). The infuriated king ordered the heat of the furnace to be intensified, his most mighty men to bind the Hebrews and fling them into the fire. Though the heat was so intense that the soldiers who cast them into the furnace were slain, the Hebrews were seen walking loose in the fire without any hurt. Equally astounding was the fact

that a fourth one was seen with them. (2) The convinced king (vv. 26-28). The spectacle was so wonderful that the king called the Hebrews together out of the fire. They came forth unharmed, for the fire had no power over their bodies; not even a hair of their heads was singed, their coats changed, nor the smell of fire upon them (v. 27).

(3) The king's decree (v. 29). This was most foolish and wicked. Even a king has no right to kill people for not worshiping God.

(4) Promotion of the Hebrews (v.

Their fidelity in this trying ordeal resulted in their promotion instead of downfall. May we learn from this that:

(a) God alone is Lord of the conscience. One's faith and worship should be determined by the individual before his God. No church, king or ruler has a right to interfere. (b) We should meet religious intol-

erance by being obedient to God rather than man. (c) God will support those who are

faithful. (d) We should prepare for flery trials, and through them all be true to our conscience.



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