An Inventory of Granular Materials in Indiana

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Of the many improvements in the design of highway pavements during the past two decades, it is doubtful that any have been more important to the life and service of the pavement than the incorporation of the granular base course as a design feature. The true significance of the base course can be more thoroughly understood if one considers the merits of this practice. First, the properly designed base course increases the load-carrying capacity for a given pavement structure and therefore increases its ability to support wheel loads. Second, the granular base course, if properly designed, serves as a drainage installation, thus enhancing the rapid removal of surface water and thereby alleviating the tendency for water to accumulate beneath the pavement. This is of extreme importance, since surface water and soil moisture always complement pumping, frost heaving, subgrade softening, and materials disintegration.

Highway engineers have been quick to recognize the value of base courses; however, even as late as ten years ago, when many of our existing highways were being built, there were numerous instances where the loads and the volume and intensity of traffic did not warrant the additional cost of base-course construction. However, with the advent of the modern motor-freight truck, the wheel loads and the heavy truck traffic have been increasing constantly. This has been particularly true since the start of the national emergency, thereby accelerating the distress and failures of many of our pavements. And as one might suspect, other things being equal, the pavements having the granular base courses as well as those on gravel terraces and granular soil areas are showing superior performance.

In view of these introductory statements on base-course design and construction, it seems reasonable that post-war highway plans will be unanimous in the adoption of the granular base course for roads carrying heavy traffic and located in certain soil areas. And with the vast amount of post-war highway planning that is in progress by our federal, state, municipal, and county officials, it seems to be a foregone conclusion that when post-war-highway construction programs get under way, there will be an unprecedented demand for large quantities of low-cost materials suitable for the construction of base courses.

In this regard, Indiana, like many of the states in the north-central region, enjoys a most favorable position, since about four-fifths of her total area lies north of the glacial boundary. Therefore, glacially deposited granular materials occur throughout a large part of Indiana. In some areas these deposits are small and isolated, while in other areas the deposits may be abundant and may occupy areas measured in square miles. This suggests that granular materials have an economic as well as an engineering significance, and rightly so, since in localities where

Fig. 1. A ground view of a kame showing the hummocky topography characteristic of this type of deposit.

granular materials are scarce the cost of granular base-course construction may be an expensive item of the road contract. In such areas the increased cost may be attributed to either the granular material itself or the long hauls necessary to obtain the material, or both. With these facts in mind, it is apparent that the identification and location as well as the distribution of these granular deposits is of importance to the highway engineer.

In recent years the aerial photograph has proved to be a particularly useful expedient in dealing with problems of highway engineering, and this is another instance where the aerial photograph can again be a useful engineering tool, since it provides an accurate and economical means of identifying and locating granular deposits. However, in order for the engineer to identify and locate granular deposits from aerial photographs, it is necessary that he become familiar with the methods by which he can establish their identity. In this regard, the writer prefers to divide or classify the granular deposits into two general

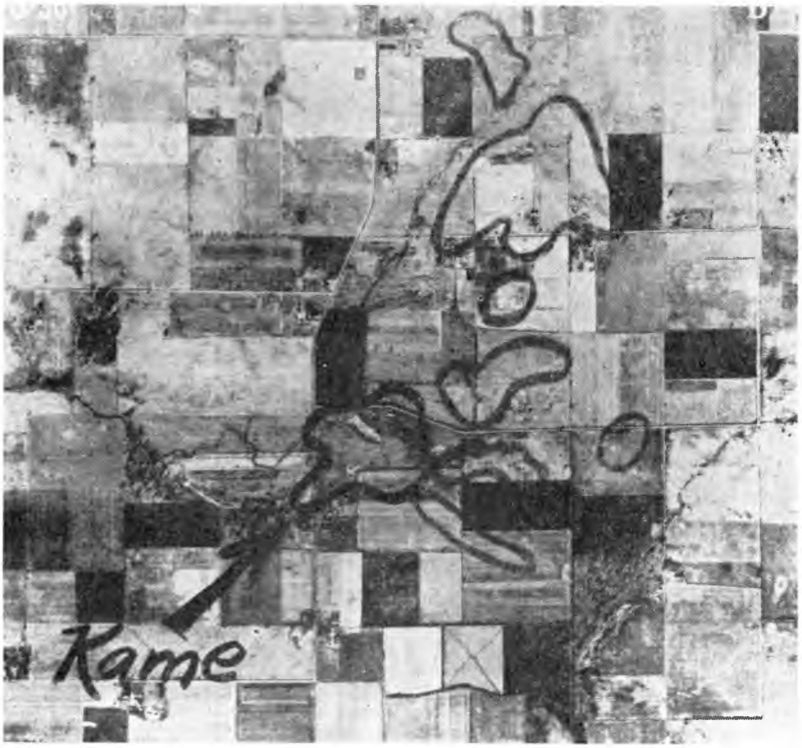

Fig. 2. An aerial photograph showing the plan sections of kame and esker deposits.

groups, namely, those which are identified directly and those which are identified indirectly; then to discuss their mode of occurrence, the criteria for their identification in the field and on aerial photographs, their relation to highway problems, and the general nature of their distribution in terms of the illustrations shown herein.

Identification of Granular Deposits

Granular deposits called kames and eskers can be identified directly in the field or on aerial photographs and are found throughout the Wisconsin-drift area. These deposits are best identified by their contrast to the surrounding topography. The kame always has the characteristic form of a mound or hummock which seems to rise abruptly in the panoramic scene. Fig. 1 is an example of the kame deposits as seen from the ground.

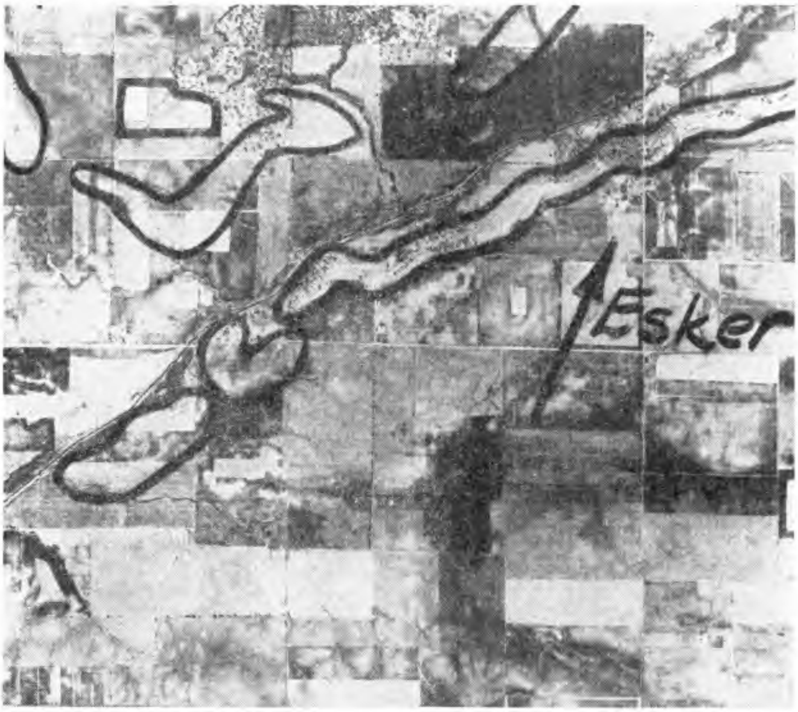

Fig. 3. An aerial photograph showing the outline of the serpentine ridges which identify the esker deposit.

Both kames and eskers can be identified and located on aerial photographs by viewing stereoscopic pairs of photographs with a stereoscope. In this way one gains the impression of topography and is able to inspect the topographic forms of several square miles in a very short time. If the engineer is familiar with the form of the kame and esker as seen from the ground, the limits of these types of deposits can readily

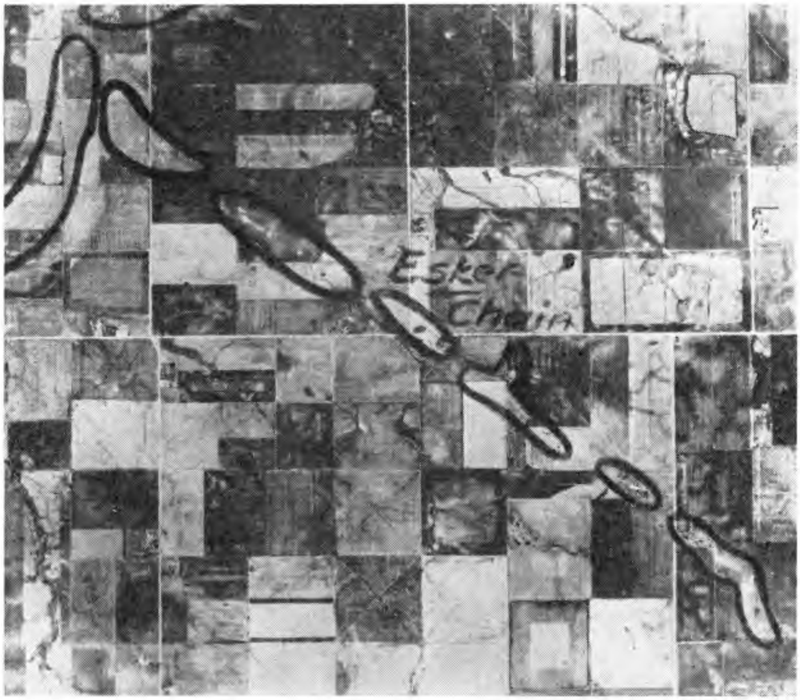

Fig. 4. An esker chain outlined on an aerial photograph.

be delineated on the photographs while viewing them through the stereoscope. This procedure was used in outlining the kames and eskers on the aerial photographs shown in Figs. 2, 3, and 4.

Fig. 2 is an aerial photograph of an area which includes a group of both kames and eskers. These deposits have been outlined to illustrate the irregular plan sections that may be expected. Within the boundaries of the deposit indicated by the arrow, a light-colored area can be seen. This is a gravel pit which has been opened in the side of the kame. It is interesting to note that by ordinary standards a considerable amount of gravel has already been removed, yet the amount that has been removed is but a fraction of that which is available.

The esker is also a mound-shaped deposit; however, it is elongated and often curves and weaves about in serpentine fashion as do the deposits that have been outlined on the aerial photograph shown in Fig. 3. This type of granular deposit may form a continuous or broken ridge that sometimes extends for several miles, as is shown in either Fig. 3

Fig. 5. A ground view of two small eskers.

or 4. In both of these figures the diagonal across the photograph represents a distance of 3¾ miles.

Sheet erosion on the steepest slope of the sides commonly occurs on both kames and eskers. In such cases the eroded surfaces are usually shown on the aerial photograph. An example of this is shown in Fig. 4. Note the light tones occurring near the center portion of each esker. Erosion surfaces as shown in this figure may sometimes serve as a guide or indicator in locating eskers on aerial photographs.

A ground photograph of two small eskers as viewed along their axes is shown in Fig. 5. One of the eskers appears in the immediate foreground and the other one is a little further removed and to the left.

An esker which has been opened and is producing sand and gravel is shown in Fig. 6. This figure helps to illustrate that the kame and esker deposits have some practical features that make them suited to highway construction. First, since they stand well above their surroundings and therefore have excellent drainage, they are accessible during all seasons and with all types of equipment. Second, the stripping is always light, therefore reducing the cost of opening the deposit.

While the kame and esker deposits of granular material occur throughout the Wisconsin-drift area, their distribution is indiscriminate and unpredictable. In some areas this type of deposit is abundant and, in others, kames or eskers occur singularly. On the other hand, the deposit may be quite large and it may contain large quantities of material; yet in other places it will be small and occupy little more than a ground swell in the surrounding topography. It is unfortunate that the distribution of this type of deposit is so promiscous; however, if the engineer is familiar with the characteristic form and shape of the kame and the esker, he can locate them easily in areas where they exist, either by field inspection or from aerial photographs.

The second group of granular deposits that occur in Indiana consists of outwash plains and gravel terraces. The writer chooses to think of these deposits as being identified by indirect methods, since it is the identification of the drainage characteristics of the granular material which are reflected in the aerial photograph through erosion, color tone, the habitat, the occurrence of sand bars in the streams, etc., that guides us in locating these outwash plains and gravel terraces.

The identification of the drainage characteristics on the aerial photograph is paramount to locating either the outwash or terrace deposits, since these deposits frequently occur in areas of several square miles, and the perception of the human eye is dwarfed by their vastness. Therefore, the engineer must rely almost entirely on the aerial photograph as a means of identification.

Fig. 6. An esker that is producing sand and gravel.

Two examples illustrating the technique employed in identifying the drainage characteristics of granular material are shown in Figs. 7 and 8. Fig. 7 is an aerial photograph of an area in northern Indiana. This photograph was taken during the early spring months after a heavy rain. Note the light feathery lines extending on either side of the open drainage ditch which passes diagonally across the picture. These light lines are the outlines of the farm drainage system which, though buried beneath the ground, is clearly outlined by virtue of the fact that the area in the immediate vicinity of the drain dries out faster than the areas more removed from the drain. Therefore, the light tones in the photograph reveal the location of the farm drains.

Fig. 8 is an aerial photograph of an area in northern Tippecanoe County which contains an isolated sand ridge that has been outlined on the photograph. It is important to note the contrast of color tones when comparing those of sand ridges with those of the adjacent area. Both Figs. 7 and 8 serve to illustrate that color tones in aerial photographs reflect the drainage conditions present. In Fig. 7 the effect of drainage was produced artificially by means of drain tile, whereas in

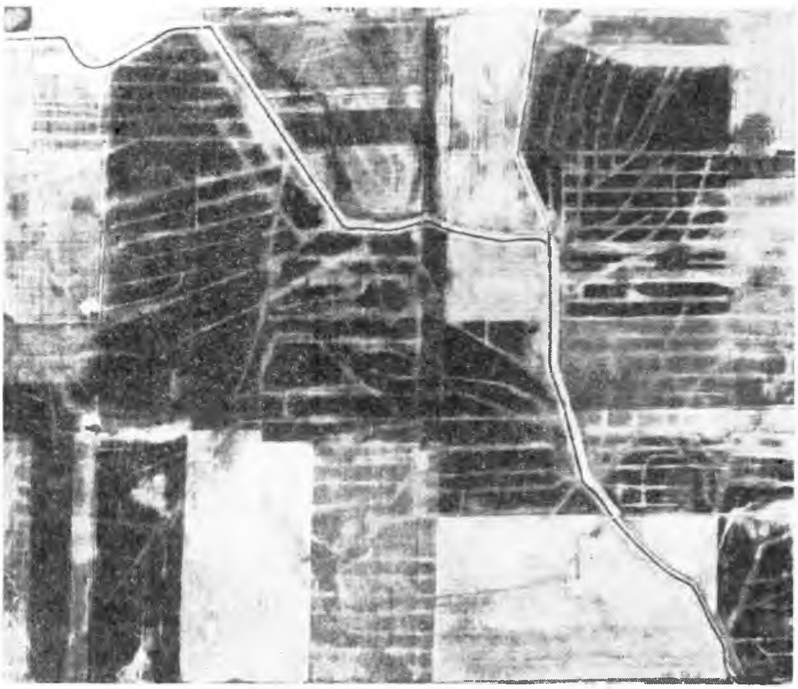

Fig. 7. An aerial photograph showing the location of subsurface tile drains through the medium of color tone.

Fig. 8. Contrasts in color tones reflect the contrasts in drainage characteristics.

Fig. 8 it was produced naturally by the sandy material. It is important to note that in either case the cause and the effect are the same. Also, these two figures serve as a demonstration of the merits of granular-base courses as a drainage facility.

The blanched color tones of the sand ridge shown in Fig. 8 are characteristic for sands. A large part of northwestern Indiana is covered with a fine sand. This area is confined largely to the Kankakee River basin. Sand dunes are numerous in this area and can be identified either by this characteristic blanched color or by the scrub oak trees which thrive on this sandy soil. An aerial photograph of such an area is shown in Fig. 9.

Another characteristic of outwash and terrace granular deposits that is reflected in the aerial photograph is the absence of surface-erosion or surface-drainage development. In Fig. 10 is shown a group of aerial photographs which have been matched to form a small mosaic map. The area shown includes the Wabash River, which appears in the upper part of the figure, and the terrace areas on either side of the

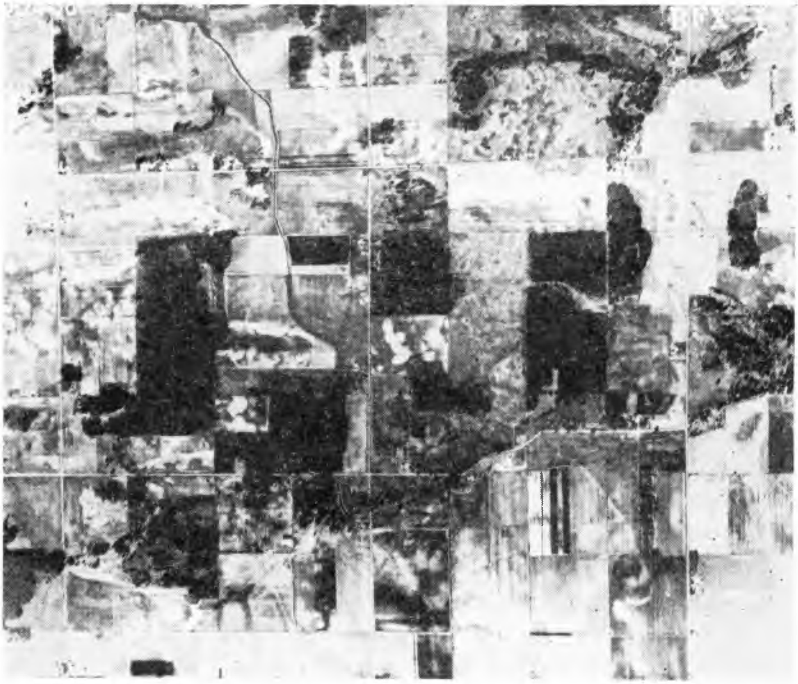

Fig. 9. An aerial photograph of the sand-dune area of Northwestern Indiana.

river have been indicated. It is important to note the contrast in the amount of surface-drainage development on either side of the southern extremity of the terrace deposit. A close-up of this locality shown in Fig. 11 brings out the details of this contrast. This contrast is even more marked in the upper portion of the map, where severe erosion gullies occur adjacent to the terrace. The reason for this contrast in surface erosion or surface drainage can again be attributed to the contrasts or differences in the drainage conditions. In one area, the soil is relatively impervious to water, and therefore the surface run-off moves horizontally over the surface. In the other area, the soil being granular and highly permeable, the run-off is moved vertically and downward to where it eventually finds its way to the river. It is interesting to note the small stream which enters the terrace area just below Section 9. The stream flows north and west to a point just west of Section 5, where all evidence of surface drainage stops abruptly. This is an excellent demonstration of the two types of drainage mentioned above and, incidentally, this small stream is appropriately called Lost Creek.

Fig. 10. An aerial mosaic of an area showing the Wabash River. Erosion and color tones identify the gravel terrace bordering the river.

Another contrast which the terrace area of Fig. 10 has with the adjacent area is that of general color tone. This technique was mentioned earlier and is well demonstrated in this figure by the consistently lighter color tones which prevail in the terrace area. The reader's attention is called to the light blanched tones that occur beyond the southern limit of the terrace area. These tones compare very closely with the ones shown in the aerial photograph of the sand dunes and ridges. (See Figs. 2 and 3.) A field inspection of this area will confirm the inference that these, too, are sand dunes.

Fig. 11. A close-up view from Fig. 10 showing the contrasting erosion and drainage development which exist between the gravel terrace and the upland area. The light, blanched tones are indicative of sand. An esker is also shown.

For the convenience of the reader, the sections have been marked on the photographs shown in Fig. 10. This was done in order that he might get a conception of the large areas that are sometimes covered by granular terrace deposits. The particular deposits shown here have been reported to yield clean sand and gravel to a depth of 60 to 100 feet. Therefore, this particular deposit is a potential source of enormous quantities of granular material.

Granular terrace deposits of this type and the outwash plains of northern Indiana, as well as being good sources of base-course material, are also excellent location sites for both highways and airports. The more desirable features are the level topography which is characteristic of terrace positions, the excellent drainage qualities of the natural in-place granular material, and the availability of base-course materials. Therefore, it seems reasonable that future highway and airport planning in the vicinity of granular terrace and outwash deposits will make full use of these natural advantages.

Like all the other granular deposits, the outwash plains and terraces were assorted and laid down by glacial melt waters. In the case of the outwash plains, the general location and distribution of the major areas is in the extreme northern part of the state. However, the granular-terrace deposit is distributed throughout the entire Wisconsin-drift area. And as the name suggests, they are always found in association with rivers and streams. Naturally, there are hundreds of small deposits which occur along the smaller streams. Many of these can be identified in the field as well as on aerial photographs. Figs. 12 and 13 are ground and aerial photographs of a small terrace. In Fig. 12 the terrace occupies the bench or shelf-like position between the stream and the upland which appears in the background. Fig. 13 shows this same area as seen from above. The arrow indicates the direction of the

Fig. 12. A ground view of a small terrace.

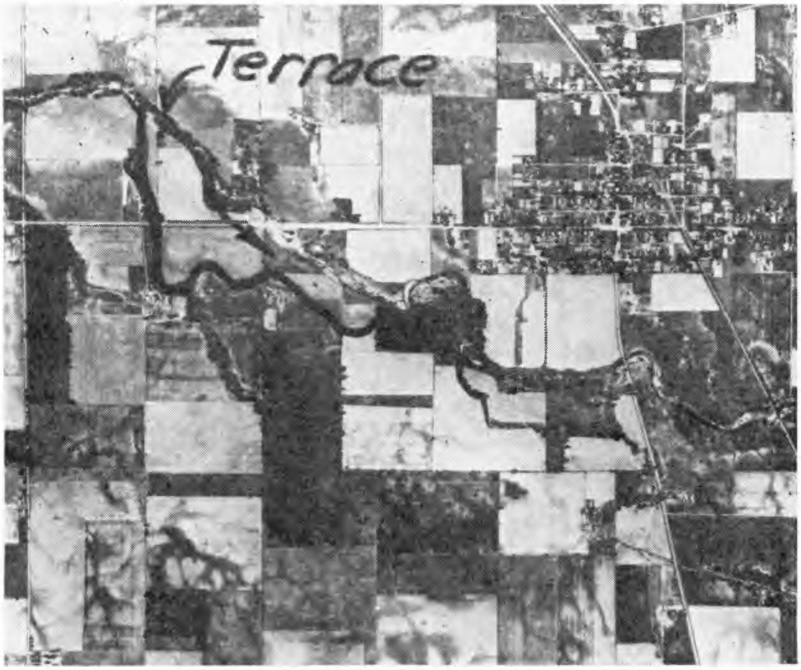

Fig. 13. An aerial photograph of the stream terrace shown in Fig. 12. (The arrow indicates the direction of view.) The sand bars in the stream are another indication of granular material.

ground photograph. In this terrace area the same qualifying light color tone is present and surface drainage absent, thereby indicating porous granular material beneath the surface. Also, note the sand bars that occur in the stream. Their occurrence is usually an indication that granular material can be found in the vicinity.

In order for the highway engineer to make the fullest application of the methods and techniques of identifying granular deposits, it naturally follows that the type as well as the location of the granular deposits for any given area should be compiled in the form of a map. This map should also show the location of highways. A sample map has been prepared for Tippecanoe County and is shown in Fig. 14. (See insert.)

Tippecanoe County, like many of the other counties along the Wabash River, has large areas of gravel terraces. Also, kame and esker deposits are numerous in the southern part of the County. These and other deposits are indicated on the map as well as the highways which traverse the County. By means of such a map the highway engineer is able to associate the problems of highway location and highway construction, which he encounters in the field, with the distribution of granular materials as they occur in nature. In other words, since nature has created certain soil areas which in turn give rise to some of our critical highway problems such as pumping, frost heaving, etc., it therefore follows that we should take every advantage of the favorable conditions and circumstances which occur in nature.