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STATE HIGHWAY DEPARTMENT
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State Highway Commissioner

CONDITION SURVEY, US-2

WAKEFIELD TO IRON RIVER, U. P.

Wm. Broughton
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Research Project 53 F-30

Research Laboratory
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This report presents the results of a comprehensive condition survey of all concrete projects located on US-2 between Wakefield and Iron River in the Upper Peninsula. The Survey was made in June, 1953 at the request of W. W. McLaughlin, Testing and Research Engineer. Roughness measurements were included in the physical evaluation of each project. Also, a soil profile was made at various locations along the route.

The report includes a general summary of facts related to the findings of the condition survey and suggested recommendations for correcting or improving the several projects for consideration in connection with a betterment program. This is followed by a detailed discussion of each project, supplemented by photographs illustrating the various conditions encountered during the inspection. A map showing the location of the various projects on US-2 and a tabulated summary of construction variables are appended.

GENERAL SUMMARY

Due to the terrain over which this route is located, many soil series were encountered and the grading methods now used to take care of the variable abilities of these soils to support a slab were not taken into consideration either in the design or during construction.

In many of the transition sections from fill to cut or from cut to fill, no provision was made to remove the highly organic topsoil encountered and to replace this with stable subbase material as now specified. This has resulted in many frost heaves developing on this route as illustrated by picture (18) taken at Sta. 643 + 50, Project 27-29, C4.

Another surface condition encountered over many swamp sections was the warping of the slabs longitudinally by the settlement of the transverse joints. In many cases, the settlement was as much as 1-1/2 inches below a straight line measured by stretching a string over the joint from a point 10 feet back from the joint to a point 10 feet ahead on the next slab, both points being parallel to the pavement center line. Picture (29) of pavement between Stas. 1413 to 1467 of Project 27-31, C5 shows this condition. The grade line used here was at least 3 feet too low and a fill of 2.5 feet of suitable sand subbase should be placed over the existing pavement and a new surface constructed. This would require a new drainage design to be provided, since the existing ditches and structures would be inadequate. The surface found in conditions like this is very hazardous for any trailer combination to use because the constant whipping up and down tends to break the vehicles apart. This particular condition, called locally "Galloping Gertie", is in a section of US-2 that should be studied for possible relocation and reconstruction because of the many hazardous sections encountered due to inadequate alignment and grade used when building this part of US-2.

An apparent failure of one type of center line installation, called the "ribbon" and placed by the use of a machine named the "Cleft Plane", has shown up on nearly all of the projects on which it was installed, as the centerline of the pavement has disintegrated or spalled out to the depth of the narrow felt installed and in some cases has opened up to a width of 5 inches making a traffic hazard. Picture (4) taken at Sta. 277 + 50 on Project 27-24, C3 illustrates this condition. Notes taken on construction show that the contractor's men had much trouble installing this joint and that a porous condition of the concrete slab at the center line was noticed on some of these projects before the first winter started. Painting this was suggested as a possible remedy. This type of center joint installation is not used at present.

On nearly all of the projects inspected, failure of paving slabs over existing culverts has developed, due apparently to inadequate cover provided to prevent frost action. Because of this inadequate cover, the culvert rises when freezing takes place and then fails to settle back when the grade thaws in the spring. This, in effect, makes a knife edge or fulcrum support for the slab immediately over the structure with no continuous support for the balance of the adjacent pavement. Under such conditions the pavement is easily cracked by traffic. Picture (8) at Sta. 443 + 70 of Project 27-29, C2 illustrates this condition.

Another type of failure over culverts, due to inadequate compaction of the fill at a culvert site, is illustrated by picture (7) taken at Sta. 509 + 06 of Project 27-29, C2.

The slab failures referred to above require relaying or replacement of the structure at the proper elevation together with compaction of the back-fill and the repair or replacement of the surface slab that has been destroyed.

The transverse joints have developed many types and degrees of failures. In many cases, the expansion joints have closed very tightly and are not functioning as expansion joints. These joints have spalled due to foreign material getting in the joint and causing the slab edge to crack out when the pavement expanded. The contraction joints are also badly spalled and have foreign material in them. This condition is caused largely by the joints not having had enough maintenance attention and being left open when traffic displaced the joint sealing material, thus allowing water and loose stones to get in the open joints. On many projects, a hinge or warping joint was constructed between expansion or contraction joints. In many cases it was observed that the reinforcement running through these joints was broken, thus allowing the joints to open and act as contraction joints. Pictures (24) and (25) taken at Sta. 954 + 75, Project 27-31, C4 show typical spalling condition at hinge or warping joint. These joints

now exhibit the same type of failures already referred to. Picture (5) taken at Sta. 303 + 23, Project 27-24, C3 shows a typical contraction joint that is open, with material inside of joint causing spalling.

Scaling of slab surfaces varies for each project with the worst of this condition showing up on the younger projects, indicating that the age of the concrete before the use of NaCl or $CaCl_2$ to help remove icing has some bearing on the amount of scaling that develops. Picture (32) taken on Project 27-5, C2 looking west from Sta. 916 illustrates the general good surface found on the older pavements. This project was paved in 1928-29. Picture (33) taken of surface on Project 27-20, C6 illustrates scaling on a project paved in 1940. There was a difference of about 11 years in the aging of these pavements before chemical ice removers were used.

All of the above conditions that have been encountered between Wakefield and the junction of US-2 with US-45 just south of Watersmeet can be found on the projects easterly of this junction, either in Gogebic or Iron Counties. Pictures (41 and 42) illustrating the longitudinal cracking of concrete pavement because of frost heave material were taken at Sta. 538 + 50 of Project 27-20, C9.

On Project 36-17, C2 which was constructed without the placing of load transfer devices in the transverse joints, pictures (49 and 50) taken at Sta. 409 + 75 show plastic flow of grade material carrying a section of pavement bodily sidewise. Also, on this project which has numerous sections of heavy grades up to 7.0 percent along with short vertical curves at the grade intersection, pictures (51 and 52) taken at Stas. 316 and 412 show what happens when the drainage structures are clogged or inadequate to handle the surface run-off from a heavy storm. The pictures illustrate conditions after a 2-inch rainfall of less than an hour duration on the night of June 30, 1953. Later examination of these structures by Mr. Downey, Maintenance Engineer, revealed that

a log was blocking the culvert at Sta. 412 and at Sta. 312 form lumber was still in place in the culvert, thus materially reducing the effective area of these structures.

On Project 36-17, C2, records show that four different kinds of cement were used and the location of these changes can be visually noted by the different appearance of the pavement surface. Picture (55) taken at Sta. 383 + 40 looking east shows pavement constructed using Huron cement while picture (56) taken at Sta. 425 looking west shows pavement surface where Aetna cement was used. The general crack pattern of these changed cement sections remains the same.

On Projects 36-17, C3 and C4, the pavement surface is in excellent condition which probably can be attributed to the fact that the natural soils over which these are constructed are basically better material than found further west.

There was a short concrete capping section constructed on Project 36-17, C4 which is in excellent condition although 18 years old now. The design used for this capping differs from the present standard usage in that the joints in the existing 18-foot concrete pavement were matched by the joints in the capping and only a heavy oil was used to break bond between the existing and new concrete.

Although many different materials were used in constructing the concrete pavements found on these projects between Wakefield and Iron River, the condition of the surface brings out very pointedly the fact that the road surface is only as good as the grade that it is laid over. Most of the failures can be attributed to the lack of stability of the subgrade soils because of saturated grade condition immediately below the slab.

PROJECT INFORMATION

This section includes a detailed discussion of each project covered by the survey. Information is given on the condition of the surface, condition of the joints, subgrade soils, construction information from district files, and general remarks.

Pictures illustrating various conditions are included with each project. The projects are discussed in order of their occurrence on US-2, starting at Wakefield and ending at Iron River.

Project 27-24, C3; Wakefield S. E.

Surface: In general, the surface of the concrete is good (see Pictures 1 and 2). The project has slight cracking from frost action mostly at rock excavation locations due to poor transition drainage. Most drainage structures have heaved or settled causing pavement cracking; (Picture 3 illustrates this).

Joints: The longitudinal center line joint was a 1/8" felt ribbon installed by a cleft plane machine. This has deteriorated on about 70 percent of this project and has spalled the full depth of the felt, leaving a dangerous condition that could possibly cause an accident. Most expansion joints have closed as tight as possible and are in good condition. The majority of the contraction joints are closed with slight spalling and faulting. Those that are open generally have loose rock particles in them and are spalled. The hinge or warping joints, in general, are open and acting as contraction joints; the original filler has disappeared and the joints are spalling. Pictures 4, 5 and 6 illustrate joint conditions.

Soils: The soils consist of Munising and Adolph. The "C" horizon in the Munising, in most cases, is a loam with layers of sandy clay, clay loam, and sometimes a clay, which creates a perched water table responsible for the wet subgrade found on parts of this project.

Construction Information: Records show that the sand subbase used, which varied from 8 to 24 inches in depth, was classed as borderline material and that the contractor had trouble getting batch trucks up to the mixer and was forced to use

reinforcing steel mats as duckboards. Also, a general note was made that the subgrade was rutted and wet. The mix used was 6 sacks of cement to 1 cu. yd. of concrete.

Remarks: Pumping was in evidence over parts of this project and the drainage outlets are not working well - possibly blocked by down timber or beaver dams; also ditches show evidence of high water table. Drainage could be improved by ditch cleanout to a depth of 3.5 feet and a width of 4.0 feet. Ditch outlets should be examined and cleaned out if necessary. Some culverts should be relaid to present day standards.

Project 27-29, C2; US 2, East of Wakefield

Surface: In general, the concrete is good but averages 1 to 3 cracks per slab. Parts of this project are in good riding condition, although some are very rough due to pumping and slabs warping. There are some scaled areas but these are not progressive as they have been noted in earlier surveys. At most culvert locations, the surface has been cracked either by the culverts heaving or by settlement of fill over culvert. Pictures 7, 8, 9 and 10 illustrate these conditions.

Joints: Approximately 90% of the transverse joints are faulted and this faulting varies from 1/8" to 3/4". The longitudinal joint is open and faulted sporadically. All joints and cracks show lack of maintenance and are badly in need of filling. In one location station 548 + 70 a crack in the shoulder was found directly in line with the joint which was badly faulted. This is shown in picture 11. Picture 12 shows an open center joint at station 444 before spalling has started.

Soils: The soils found on this project consist of the following series: Munising, Adolph, Bergland and peat. The Munising requires an 18" sand subbase with 3.5 x 4.0 R. B. Ditches. The Adolph and Bergland require at least 3.5' fill, 4.0' more desirable. The existing grade line is from 1.5' to 2.5' low. This is aggravated by very poor runoff of drainage system. The section between station 441 + 00 to 495 + 00 often has spring water flowing over the grade.

Construction Information: The plans for this project were designed by Gogebic County Road Commission. The mix used was based on 6 sacks of cement to the cubic yard of concrete. This project was penalized for thin pavement although concrete cores cut from the pavement averaged only 0.01 inch below the proper thickness. The same fall this was constructed, it was noted that the concrete along the center was porous in several locations and that maintenance should repair this condition by painting the center line. Also, a general note was made that this contractor had a tendency to over-finish pavements.

Remarks: While a bituminous resurface will temporarily improve the riding quality of this project, it will always require a large amount of maintenance as the grade in general is too low. The entire drainage system needs restudying and redesigning especially the outlet ditches. The raising of the grade with a good granular subbase over the present pavement and the placing of a new concrete slab will be necessary before this will be a satisfactory highway. Pictures 13, 14, 15 and 16 illustrate these faults.

Project NRH 27-29, C4; US 2, West from M 64

Surface: This project was constructed with 1" expansion joints, spaced at 60' intervals, using a translode expansion joint base for load transfer. A dummy was placed midway between expansion joints, thus making 30' slabs of this pavement. The slabs average 1 crack per slab, located generally at or near the midpoint of the slab, although in transition locations and swampy locations, where frost heaving and settlement could be looked for, the number of cracks per slab increases considerably. See picture No. 17. At a large number of culvert sites the pavement is badly broken up due to movement of the grade adjacent to the structure. See picture No. 18. There are also patches of heavy scaling; these have been noted previously but are now progressing rapidly towards failure. See picture No. 19.

Joints: A considerable portion of the centerline joint is open and badly spalled to a sufficient extent to create a driving hazard at moderate driving speed. Most of the expansion joints are closed but show little spalling. The majority of the dummy joints have opened up and are badly spalled and faulted; this faulting varies from 1/8" to 3/8". Sections of this project show definite evidence of pumping of joints, cracks and along edge of slab.

Soils: The soils found on this project consist mostly of Munising, Adolph, peat, with some Hiawatha. The condition of the pavement placed over grade built from this Hiawatha soil is much better than that over the other soil types. The peat areas apparently extended deeper than the original soundings indicated. The plans show that at the large span culvert over the Little Presque Isle River, it was necessary to use nearly 2700 lineal ft. of piling on account of poor foundation conditions encountered. This was done by authorization. The settling and destruction of the paving surface on the approaches to this structure indicate the existence of poor subsoil at this location.

Construction Information: The mix for this project was based on 6 sacks of cement to the cubic yard of concrete. Paving started on this project on October 7, 1935.

The mix was very slow in setting up, which made it necessary to delay finishing until 5 or 6 hours after the concrete was poured. As a consequence, the finishing was poor on parts of this project. It was noted that the center and transverse joints were reported as being left in poor condition and also that the premolded fibre joint filler broke up very easily when touched, which contributed to the making of poor joints. The method of installing joints was changed at the suggestion of District Engineer and this resulted in an improved joint. On October 11, the District Engineer ordered the Contractor to stop paving because of cold weather, however, the Lansing office ordered the contractor to continue as long as possible. He paved on until October 16 and then shut

down until the following June. Also, on July 1936, a note was made that the water control on the mixer was out of order making the mix too wet, and that the contractor's method of installing expansion joints was not satisfactory and the District Engineer was so notified.

Remarks: The grade line in general is too low, and top soil was placed directly under the slab in many transition places. The type of grading section used did not provide for enough ditch volume to carry the spring runoff without softening the slab support and causing much cracking due to high water table during a large part of the year. Evidence of frost heave material under the slab was confirmed by borings taken alongside of the slab by soils men following this survey and reported by Bessonen.

The project should be redesigned with special attention paid to a higher grade line, the type of soil placed under the slab, and a drainage system designed to carry away the runoff.

Project 27-31, C4; US 2, East from Jct. M 64 to Pelton Creek

Surface: The concrete surface of this project is generally good. However, there are spots where operations by the contractor in grading or other contractors for public utilities has caused surface damage: (1) settlement of grade due to the construction of a water main after paving, picture No. 20. (2) heaving and breaking of slab because of a boulder under the slab being too close to the surface, picture 21 (3) settlement of grade because of poor fill consolidation at R. R. crossings, bridge approaches or over culvert sites.

Joints: The longitudinal centerline joint is in fairly good shape. The expansion joint load transfer used here was Translode Expansion Joint Base and these are in general in good condition. Pictures 22 and 23 illustrate expansion joint conditions. The dummy joints are open and,in general, acting as contraction joints, and are in need of maintenance. Pictures 24, 25, 26 and 27 show various dummy joint details.

Soils: The soils found on this project consist mostly of Munising, Adolph and peat. Also ledge rock is evident in several locations.

Construction Information: The mix used was 6 sacks of cement to the cubic yard of concrete. The centerline joint was installed with a cleft plane machine.

Remarks: This project was the first in the Upper Peninsula to have a sand subbase 8 inches thick. Later projects are constructed with from 1.5' to 2.0' subbase over the soil types encountered here. Drainage structures need to be redesigned to present day standards and ditches deepened and widened with good outlets provided and then the drainage system maintained in good operating condition. Borings were taken on this project and a high water table was found where low grade line was in evidence. With some grade raising and a better drainage system constructed, this project could be given a bituminous resurface and should handle traffic satisfactorily.

Project 27-31, C5; US 2, From Pelton Creek to Gogebic Station

Surface: The concrete surface is warped and very rough. This condition is due to the many bad soil sections where frost heaving or grade settlement has occurred. This is not a material failure but is due to design and grading methods used on construction.

This project was partially surfaced in the fall of 1936 and many frost heave areas developed the first winter resulting in pavement cracking. Several subgrade drainage sections were recommended as a result of the first winter's heaving. See pictures 28, 29 and 30.

Joints: The longitudinal center joint is sporadically spalled and open. Picture No. 31 illustrates this as well as showing a definite change of cements used on this project. The transverse joints are faulted from 1/8" to 1/2" generally and are spalled in varying degrees according to the underlying supporting material.

Soils: The predominate soil type on this project is Munising with rock ledges and muck swamps crossing the road location. The sandy material used as back fill in swamp areas appears to be hard to consolidate causing faulting and warping due to poor supporting value of this sand when the water table is high.

Construction Information: The mix used was 6 sacks of cement to a cubic yard of concrete. A letter from F. J. Hagen to District Engineer McKevitt noted many sections in distress after the first winter. This letter also called attention to the lack of proper drainage for pockets where ledge rock was encountered. Also the weekly progress reports show many days when the grade was soft and trucks caused rutting in getting up to the paver.

Remarks: This project was constructed without any sand subbase with shallow 2.5' x 3.0' R. B. ditches, and in general a low grade line. Also, no attention was paid to soil selection in grading except in some swamp areas where excavation of peat and backfilling with a fine sand material was done. Due to a high water table, pumping has occurred and the slabs have warped so badly longitudinally that the pavement slab edge looks like a normal crowned section of surfacing and is very rough riding. Borings taken along the pavement edge in swamp areas showed the water table was only 2.0' below the top of the pavement and that the sand used for fill here tended to flow away from under the slab.

A thorough study of the drainage system, especially outlets, is needed here to determine the minimum grade necessary in reconstruction in order to remedy the design and construction faults found in this project before resurfacing.

Project 27-5, C3; US 2, East from Gogebic Station

Surface: In general, the surface of this project is good and no failure can be attributed to the materials used in the concrete slab. This pavement was constructed in 1929

with 100' length slabs and now averages 5 cracks per slab. The distress developed in the concrete can be laid almost entirely to the low grade line with reference to the water table and the poor supporting value of the natural soils over which it is constructed.

Joints: No load transfer was provided for the expansion joints and these have faulted from 1/8" to 1/2" but are not badly spalled. The longitudinal center joint used was the metal construction type with tie bars, standard E-7-C-11-F Det. 4. This joint has not faulted and spalled like the joints using the fabric strips. Many of the slabs have warped enough so that the joints are from 1 1/8" to 1 1/4" below a line stretched from points on the slab about 15 feet each side of the joint. There is noticeable pumping at the joints and along the edges.

Soils: The soils on this project consist mostly of Munising series along with Adolph and peat with intermittent rock ledges. The cross section used on this project does not provide for adequate drainage since it has ditches only 2 feet deep. The many frost heaves that have developed due to the combination of poor soils and inadequate design illustrate the fact that a pavement is only as good as the grade it is laid on.

Construction Information: The mix used on this project was 6 sacks of cement to 1 cubic yard of concrete.

Remarks: Borings indicate that frost heave material exists under the slab and that peat was not removed. Other construction features contributing to the pavement distress were inadequate depth for drainage ditches, inadequate cover over culverts which lead to frost heaving and damage to the pavement and a high water table due to the low pavement grade line. The use of a metal center joint instead of a premolded fibre joint has resulted in a much better looking and easier maintained center joint on this project. This project should have a grade raise of selected material, many excavations of unsuitable material from under the pavement, and better alignment both

horizontal and vertical: In short, a relocation and new construction to meet present day standards which would probably be cheaper than trying to repair this with resurfacing.

Project 27-5, C2; US 2, West of Watersmeet

Surface: This pavement was constructed without reinforcement except over short stretches near drainage structures. The pavement is generally in good shape except where bad soil conditions have caused cracking due to frost heaving and settlement over drainage structure locations. Several of these settlement locations have been mudjacked. Judging by the appearance, if this concrete were cored and tested for strength, it would show a high breaking strength now.

Joints: The transverse joints had no load transfer and have faulted generally from 1/8" to 3/8" but are not spalled. Picture No. 32 shows the general condition of the surface and joints.

Soils: The predominate soil is Munising, with some Adolph interspersed with peat and crossed by ridges of ledge rock. The typical cross section called for a 2' depth R. B. ditch below shoulder elevation with no provision for a sand subbase under the slab.

Construction Information: The mix used was 6 sacks of cement to 1 cubic yard of concrete. A large part of this pavement was laid in the fall of 1928.

Remarks: The slab is cracked over practically every drainage structure either from frost heaving the structure up and breaking the slab or from settlement of approach fills either side of the structure. In many locations the slab has been removed and a temporary surface either of gravel or blacktop has been placed. To effect even a semi-permanent repair many grade, alignment, and drainage changes would be required. In fact, a study should be made as to whether a new relocation to present day standards is required here rather than a bituminous recap over the existing location.

Project 27-20, C6; US 2, from Jct. M-45 West 1.5 Miles

Surface: Extensive scaling at both ends of this contract with sporadic scaling between. A typical view of scaling is shown in Picture 33.

Joints: The joints are in good condition, with little spalling and they have had good maintenance.

Soils: Consist of Vilas, Hiawatha, Stambaugh, Newton, Saugatuck, and peat; these soils under modern construction, require a 2.5' x 4.0' R.D. ditch to take care of water from melting of snow.

Construction Information: The subgrade was mixed to a depth of 4' for a width of 26' between Sta. 0 + 70 to 1 + 40 and from 4 + 00 to 4 + 60; also bleeders were put in every 50' between Stations 56 + 50 to 61 + 75. Ray Durfee stated in a report dated 8-14-40 that the contractor was using a hand operated float. The mix used was 5.5 sacks of cement to 1 cyd of concrete. From Sta. 2 + 00 to 11 + 00 frost heave material was excavated and backfilled. A 12" sand subbase was placed from Sta. 56 + 50 to Sta. 77 + 00 of the next project.

Remarks: This project was constructed with a good grade line but ditches were too shallow and transition and topsoils were not removed. The maintenance of cracks and joints has been good. Bad scaling of pavement has occurred, apparently due to use of NaCl and $CaCl_2$ for ice control. There is one hazardous heave at Sta. 3 + 00 each winter. A soil boring was made to determine the cause which was found to be a high water table in gravelly loam.

Project 27-20, C7; US 2, East from Jct. M-45.

Surface: This project shows considerable scaling in sections and is badly cracked at numerous points of transition from cut to fill. These conditions apparently are due to frost action and are shown by Pictures 34 and 35.

Joints: The longitudinal centerline joint has spalled intermittently. Most of the expansion joints are closed and some of these have faulted as well. Most of the contraction and dummy joints are open with dirt, stones, and broken concrete in the joint. These joints are faulted from 1/8" to 3/8" on the average. Pictures 36, 37, 38 and 39 illustrate conditions of joints.

Soils: The soils found on this project are a mixture of Hiawatha, Adolph, Munising, Newton, Channing and peat with high ground water levels; the existing road ditches show this by aquatic plants and standing water in many places.

Construction Information: Transition and topsoils were not removed but some sections were excavated after subgrade inspection, sand subbase was not used, peat was excavated. Two holes were bored adjacent to the slab and frost heave material and a perched water table was found. It was necessary to provide tile drainage to stabilize the back slopes of cuts in several locations. The mix used was 5.5 sacks of cement to a cubic yard of concrete.

Remarks: Many of the transition areas are cracked due to frost heave material under the slab and these should be repaired before resurfacing. In general, the ditches should be deepened to a 3.5' x 4.0' R. B. section and outlets provided. If the frost heave sections are repaired and better drainage provided, bituminous recapping would provide a good surface.

Project 27-20, C8; US 2, Imp Lake West

Surface: Sporadic scaling on the steeper grades with intermittent heavy spalling along the centerline joint. A slight amount of transverse cracking at transition sections from cut to fill caused by frost heaving. In general, this project is in good shape and has had better maintenance of cracks and joints than those projects west of this on US-2 thru to Wakefield.

Joints: Occasional heavy spalling of the centerline joint exists, (see Picture 40) but this has been generally repaired by maintenance forces - only slight faulting at transverse joints.

Soils: The soils on this project consist of Munising, Hiawatha, Channing, Newton, Saugatuck, and peat. The peat pockets were short and deep, these were handled by Method No. 1 with some selection of backfill material used.

Construction Information: The mix used was 5.5 sacks of cement per cubic yard of concrete. The load transfer for expansion joints was Translode Angle Joint Base and has performed well. The grading of this project was done by W. P. A. forces and on the surfacing contract considerable regrading was necessary.

Remarks: The design cross-section called for a 2.5' x 4.0' R. B. ditch without the use of sand subbase. Some heaving has developed because of this. Holes were bored adjacent to the slab, which revealed frost heave material and a high water table. Removal of frost heave material and replacing of new concrete surfacing, together with 3.5' x 4.0' ditches and good outlets provided, also relaying of existing culverts that have heaved, followed later by a bituminous recapping of the entire project, are recommended.

Project 27-20, C9; US 2, Imp Lake to Iron Co. Line

Surface: In general, the pavement surface on this project is in good condition. Due to the use of selected sandy material the pavement has not faulted seriously although there has been some frost heaving, apparently due to blocked drainage of the subbase. (See Pictures 41 and 42.)

Joints: The joints are in good condition on this project, very slight scaling and practically no faulting.

Soils: Munising, Iron River, Hiawatha, Gaastra, Adolph, Newton, Channing and peat were mapped as being found on this project. The general soil condition improved on this project as compared to the several projects to the west. Another improvement was the use of a sand subbase material on parts of this project.

Construction Information: The mix used was 5.5 sacks of cement to a cubic yard of concrete. Additional tile edge drains with sand gravel backfill were placed between Stas. 434 + 50 to 442 + 00, R. & L.

Remarks: Four holes were drilled adjacent to the slab and in all cases a perched water table was found. Ditches should be cleaned out to present standards and provisions for good outlets should be made. The existing ditches and soil borings show that the water table is high in relation to the grade line. With some intermittent repairs and scattered resurfacing, this project can be in good condition to carry traffic with ordinary maintenance for a long time.

Project 36-23, C2; US 2, Iron Co. Line East to Golden Lake

Surface: Bad scaling has developed over the east end of this project, namely between stations 690 to 718 and a resurfacing project was being started here as M36-23, C 3 for 0.471 miles of bituminous resurfacing. Pictures 43, 44 and 45 show this condition. Picture 46 and the sample condition survey show the damage done by frost heaving. This project is in the worst condition of any in Iron County that was included in this survey.

Joints: Heavy spalling of center line joint along with light scaling on the west end of this project, although good maintenance has helped in keeping this to a minimum. Some faulting and spalling of transverse joints and cracks has occurred at several frost heave locations especially at transition points.

Soils: The soils on this project consist mainly of Iron River with Hiawatha, Gaastra, Channing, Adolph and peat.

Construction Information: A grade raise was made between stations 821 and 842 and ditches were constructed 2.5' x 3.0' R. B.. Peat was excavated by Method No. 2. Some attention was paid to transition areas during construction as part of subgrade correction. Load transfer was provided for at expansion and contraction joints by 3/4" x 15" dowel bars.

Remarks: Practically all expansion joints along with one half the contraction joints are closed tight, while the majority of the dummy joints are open and acting as contraction joints, although well sealed by maintenance operations. Bad heaving has developed at transition points and these should be repaired before a resurfacing project is considered.

Project 36-2, C3; US 2, Golden Lake to Beechwood

Surface: In general, the condition of the pavement on this project is good. There is a slight longitudinal warping of the slabs. There are a few blacktop patches where temporary repairing has been done. The section from P. O. B. station 430 to 546 has practically no cracking except at transition sections where some frost heaving has developed. From station 546 to 560 considerable cracking along with spalling of center joint has occurred. From station 560 to 690 P. O. E. the pavement has some light spalling along the center line joint. See Figures 47 and 48.

Joints: Except for slight spalling of the center line joint as noted above, the joints are in good condition and have had good maintenance.

Soils: The soils on this project consist mostly of Iron River series along with some Gaastra and peat.

Construction Information: The mix used on this project was six sacks of cement to the cubic yard of concrete. 2.5' x 3.0' R. B. ditches were used. Peat was excavated by Method No. 1; no attention was paid to topsoil or transition areas.

Remarks: With some minor replacement of the slab over transition areas where unsuitable soil needs to be removed and deepening of ditches to a 3.0' x 4.0' R. B. section and good outlets provided, this project will carry traffic in good shape without resurfacing.

Project 36-17, C2; US 2, Relocation East of Beechwood

Surface: In general, the surface is good. The west end of the project was constructed using Universal, Huron and Aetna cements, while Petoskey was used on the east end.

Joints: Some faulting and slippage of joints has occurred on this project because load transfer devices were not provided. Pictures 49 and 50 illustrate this side slippage at a joint location.

Soils: The soils on this project consist mostly of Iron River with Mastodon (Hiawatha) Stambaugh, Gaastra, Bergland and peat.

Construction Information: It was found that four different brands of cement were used rather than one brand as shown in our records. A mix using six sacks of cement to a cubic yard of concrete was used with all brands of cement.

Remarks: This project was designed with heavy grades running up to 7% maximum in several stretches. Pictures 51 and 52 show typical cracking observed. Due to the rough terrain, there is a very fast runoff. Pictures 53, 54, 55 and 56 show water running over grade after a heavy rain on July 1, 1953. The existing culvert at station 412 where water is shown going over the grade was later found by Mr. Downey to be partially blocked by an old log, while the culvert at station 316 was found to have form lumber still inside of it. In both cases this would reduce the capacity of the structure to handle drainage. Due to inadequate design, drainage ditches need to be deepened and widened and better outlets provided. The road ditches have aquatic vegetation

growing in them; this indicates the existence of a high water table. Holes have been bored alongside of cracked slabs which revealed frost heave material and a high water table. With some sectional repairs, this project should carry traffic without complete resurfacing for a considerable period.

Project 36-17, C3; US 2, Iron River West

Surface: This project is in excellent shape. No faulting but a few longitudinal cracks caused by fill settlement due to grading have occurred.

Joints: The joints are in good shape and have had excellent maintenance.

Soils: The soils on this project consist mostly of Iron River, Stambaugh, Bergland, and Bruce series. The topsoils "A" and "B" horizon, of Iron River and Stambaugh, will produce heaving and should have 3.0' x 4.0' R. B. ditches. The Bruce and Bergland series should have a 3.5' to 4.0' fill.

Construction Information: The mix used was 6 sacks of cement to a cubic yard of concrete. During construction the paving was held up by wet weather and notes were made of soft subgrade conditions. The method of curing was 7 days under paper followed by 21 days under wet earth.

Remarks: Some ditch cleanout is necessary with good outlets. Picture No. 57 shows longitudinal cracking where new fill was placed along side of existing fill and the new fill may have settled enough to cause this cracking. Unless traffic requires a widened pavement surface, ordinary maintenance will be sufficient here if side ditches are cleaned out.

Project 36-17, C4; West city limits, Iron River

Surface: The pavement surface of this project is in excellent shape, especially the 1450' west from 9th Street which was capping placed over a 18' concrete slab

poured earlier. (See Picture No. 58 for capping; Picture No. 59 shows condition of balance of project where regular pavement section was used.)

Joints: Some slight spalling occurs at an occasional transverse joint along with some D cracking.

Soils: The soil types are predominately Iron River and Stambaugh.

Construction Information: The mix used was 6 sacks of cement to a cubic yard of concrete. On the East 1450' from the intersection of 9th Street Westerly, existing 18' concrete pavement was capped with 20' concrete with 12" edge and a 6" minimum section. A heavy oil was used to break bond and the existing joints were matched by the joints in the capping. Paper was used for 7 days followed by 21 days of wet earth for curing. During construction the paving was delayed by wet weather and it was noted that the forms settled slightly in the capping section.

Remarks: This project is in excellent condition (See Pictures 1 and 2) and has been widened with 18" of bituminous material on each side. This 18 year old capping is in almost perfect shape and if due to traffic it is necessary to widen this pavement in the near future, it can be recapped. The placing of the new joints directly above the existing joints and the length of time allowed for curing may be contributing factors to the excellence of this surface.