

**DETERIORATION OF CONCRETE HIGHWAYS AND BRIDGES
CONTAINING BIG CUT PIT AGGREGATES**

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John C. Mackie, Commissioner
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DETERIORATION OF CONCRETE HIGHWAYS AND BRIDGES CONTAINING BIG CUT PIT AGGREGATES

Aggregates from the Big Cut Pit (No. 71-15), located in Presque Isle County 3 miles east of Millersburg and 6 miles northwest of Hawks, are known to have been used in Michigan concrete highways since 1925 and in bridges since 1949. In 1958, the Road Construction Division requested that the Office of Testing and Research investigate a 2-year-old pavement in Cheboygan where an unusually severe frequency of aggregate popouts had been observed.

The Research Laboratory Division found that Big Cut aggregates had been used for the Cheboygan pavement and condition survey records showed similar deterioration on other projects containing material from this source. The Testing Laboratory Division furnished lists of bridges containing Big Cut aggregates in March 1959 and pavements in May 1959.

Photographic Survey

In May and August 1959, photographic surveys were made in the 15 counties where the projects containing Big Cut aggregate were located, to secure pictorial evidence of the variety and degree of popout deterioration. These projects are listed in Table 1 and their locations given in Figure 1.

TABLE 1
PAVEMENTS AND STRUCTURES
CONTAINING BIG CUT-PIT AGGREGATES

County	Project Number	Year Built	Map Key (Fig. 1)	Figure Numbers
ALCONA	SSB2 of 1-9-1, C3R SSB3 of 1-9-1, C1R	1956	1	29
		1956	2	30
ALPENA	M 4-12, C1 M 4-4, C7 MB1 of 4-3-1, C1 CSB1 of 4-8-21, C1	1930	3	61, 62, 63
		1948	4	74, 75
		1952	5	16
		1957	6	39
ANTRIM	M 5-7, C5 CSB1 of 5-7-22, C1	1952	7	82, 83
		1958	8	51
ARENAC	M 6-18, C1 F 6-1, C8 M 6-27, C1 6-27, C2 M 6-16, C1 F 6-12, C1 M 06011, C1 F 06072, C1	1932	9	None
		1947	10	68, 69
		1947	11	70, 71
		1949	12	None
		1950	13	80
		1931	14	64
		1958	15	90, 91
		1958	16	92, 93
BAY	M 9-13, C1 M 9-16, C1 FGX2 of 9-15-8, CIU	1925	17	59
		1930	18	60
		1957	19	31
CHARLEVOIX	M 15-3, C6 M 15-3, C5 CSB1 of 15-13-24, C1R	1927	20	55, 56
		1928	21	57, 58
		1958	22	52
CHEBOYGAN	F 16-19, C1 CSB1 of 16-16-14, C1 F 16-12, C3 F 16-29, C3 F 16-3, C2 SSB1 of 16-3-1, C1R FB1 of 16-6-1, C2R	1931	23	65, 66, 67
		1949	24	6
		1949	25	78, 79
		1949	26	76, 77
		1956	27	84, 85
		1957	28	35, 36, 37
		1958	29	53, 54
EMMETT	24-20, C3 F 24071, C2 MB1 of 24-16-3, C1UN MB2 of 24-16-3, C1 MX1 of 24-16-3, C1UN	1931	30	None
		1957	31	86, 87, 88, 89
		1957	32	40, 41, 42
		1957	33	43
		1957	34	44, 45, 46, 47, 48, 49, 50
GLADWIN	MB1 of 26-8-1, C2R	1957	35	32, 33, 34
INGHAM	UUG X3 of 33-6-1 UB1 of 33-6-36, C1 MB1 of 33-6-2, C1	1951	36	12, 13
		1951	37	14, 15
		1953	38	17, 18, 19
IOSCO	F 35-3, C9 SSB1 of 35-4-1, C2 SSB1 of 35-8-1, C2 M 35-14, C6 FB1 of 35-5-1, C1R B1 of 35-6-12, C1	1948	39	72, 73
		1950	40	8
		1950	41	7
		1952	42	81
		1954	43	22, 23
		1957	44	38
MONTMORENCY	SSB1 of 60-5-1, C1	1951	45	9, 10, 11
OGEMAW	CSB1 of 65-10-20, C1	1953	46	20, 21
PRESQUE ISLE	FB1 of 71-1-2, C1R FB1 of 71-5-2, C2R	1954	47	24, 25, 26, 27
		1954	48	28
ROSCOMMON	FB1 of 72-8-12, C1 FB2 of 72-8-12, C1	1949	49	5
		1949	50	2, 3, 4

**BIG CUT PIT
NO. 71-15**

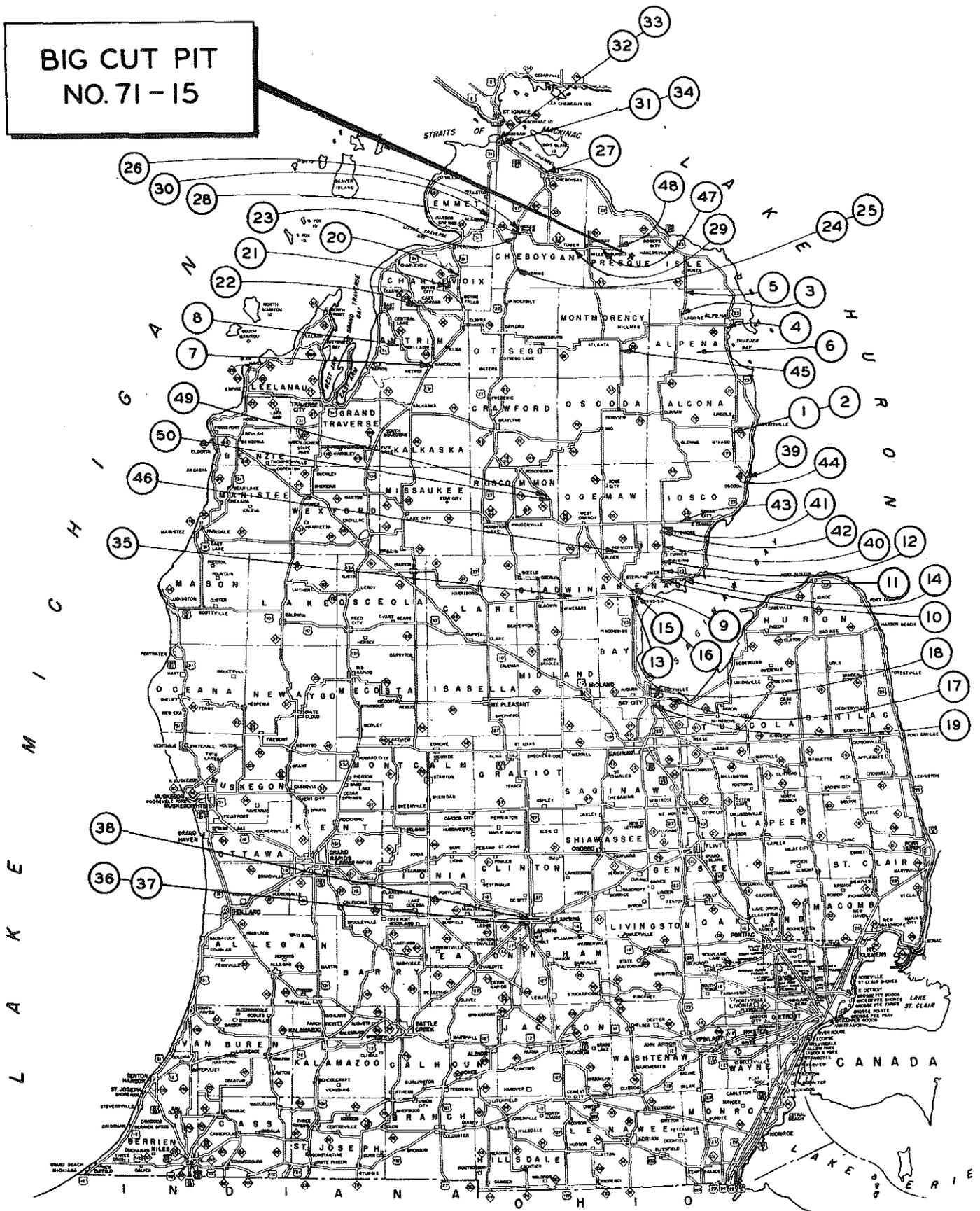


Figure 1. Locations of highway and bridge projects containing Big Cut aggregates (map key in Table 1).

Some 92 photographs are presented here, 53 showing 27 bridges (Figs. 2-54), presented in chronological order of construction, and 28 showing 19 highway projects (Figs. 55-93) presented in the same order. The illustrations show the notable frequency with which horizontal concrete surfaces containing Big Cut aggregates have developed popout deterioration.

The pattern of popout deterioration encountered on the projects indicates that the Big Cut material frequently has contained considerable percentages of deleterious rock types. Close examination of these popouts has shown that these were caused by stones approximately 1/2-in. or bigger, mainly chert, cherty limestone, and sandy or argillaceous limestones.

Laboratory Investigation of Aggregate Samples

Two samples of gravel were obtained from stockpiles at Pit No. 71-15 on August 7, 1959. It had been intended to take samples of 6A and 6B, but because 6B was not being produced, a sample of 9A was obtained instead. The 9A is a somewhat smaller grading than 6B, but is produced by crushing oversize cobbles in much the same manner as for 6B.

The two gravel samples were screened in the laboratory and examined visually. It became apparent that the majority of both samples was composed of various types of limestone and considerable amounts of chert, the latter especially noticeable in the 6A sample. Very minor amounts of igneous rock types were present.

A sink-float test was run on fractions of both samples, using a near-saturated solution of zinc bromide to measure quantitatively the amount of lighter gravity material. Such investigations as those of Legg⁽¹⁾ have established a sp gr of 2.55 as a reasonable dividing line between acceptable

TABLE 2
SINK-FLOAT TEST RESULTS FOR BIG CUT AGGREGATES

Sieve Fraction	Float Material*		Sink Material**	
	Percent of Fraction	Absorption 24-hr, percent	Percent of Fraction	Absorption 24-hr, percent
<u>6A Gravel</u>				
No. 4 - 1/2 in.	19.7	4.23	80.3	1.18
1/2 - 1	26.9	4.04	73.1	0.82
1 - 1-1/2	21.5	3.20	78.5	0.72
Average 6A Grading	22.7	3.90	77.3	0.94
<u>9A Crushed Gravel</u>				
No. 4 - 1/2 in.	9.0	5.82	91.0	1.54
1/2 - 1	7.4	4.34	92.6	1.31

* Sp gr of less than 2.54

** Sp gr of more than 2.54

and unacceptable quality for chert and other questionable rock types. The absorption values and sink-float percentages for each fraction, at a sp gr of 2.54, are tabulated in Table 2.

(1) Legg, F. E., Jr. "Investigation of Durability of Chert in Michigan Gravel Produced by Commercial Heavy Media Separation Plants." MSHD Testing Laboratory Division (1955).

It is evident from these tabulated results that over 20 percent of the 6A gravel had less than 2.54 sp gr and an absorption of almost 4 percent. Even the better quality 9A material had over 7 percent of stone of less than 2.54 sp gr and an absorption exceeding 4 percent. A separation made at a sp gr of 2.60 would result in an even higher percentage of floating material.

These results suggest an explanation for the inadequate performance of Big Cut 6A and 6B in structures and 4A and 10A in pavements, as evidenced by the unusual frequency of popouts. The characteristic lighter density of a large portion of the 6A--and also the 4A and 10A--would facilitate the concentration of this absorptive material at or near the surface of pavements or bridge decks. Of course, this would eventually lead to numerous unsightly popouts, which in turn would be focal points for further deterioration of the surface.

It is quite probable that a heavy medium separation process of beneficiation would greatly improve this material and ensure a quality product for sound exterior concrete finished surfaces. For proper beneficiation, the operating specific gravity might have to be set at such a level that a considerable amount of material would be rejected.

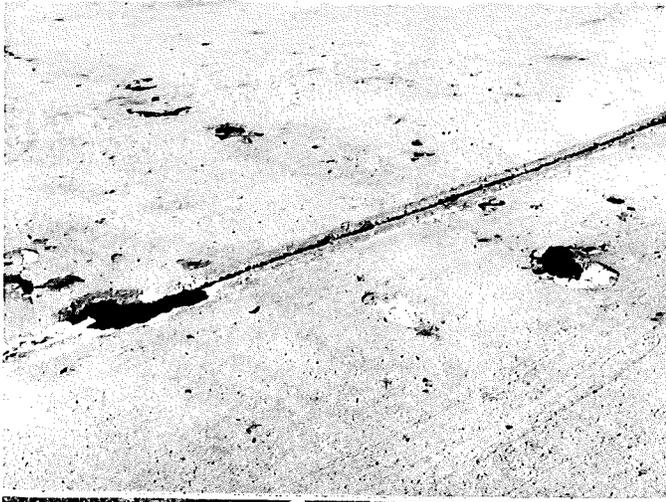


Figure 2

Figure 3

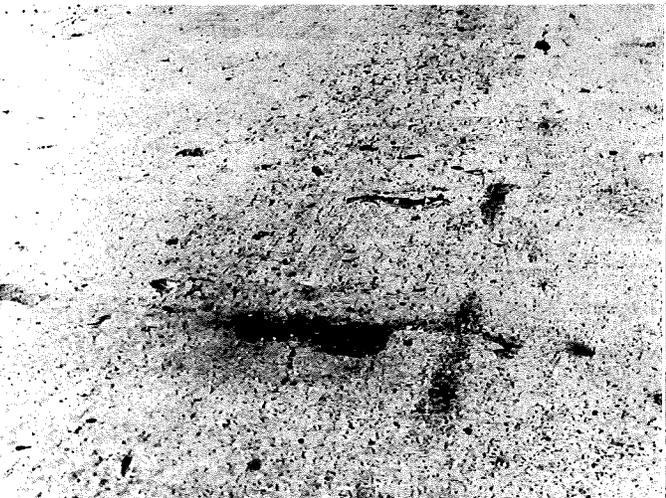


Located on M 76 in Roscommon County approximately 1.0 mi northwest of St. Helens, this structure was built in 1949. The superstructure has medium to heavy popouts, with some disintegration of railing posts. Typical popouts are shown on the deck surface (Fig. 2), curb (Fig. 3), and substructure wingwall (Fig. 4). FB 2 of 72-8-12, C1 (72092).

Figure 4

Another 1949 bridge, 3 mi northwest of St. Helens on M 76, displays similar surface conditions, these deck popouts being typical. FB1 of 72-8-12, C1 (72092).

Figure 5



This 1949 structure lies on a Cheboygan county road in the southeast corner of the Village of Wolverine. Although the substructure is in good condition and free of popouts, the deck displays this light pop-out condition. CSB1 of 16-16-14, C1

Figure 6





▲ Figure 7. Located on M 65 in Iosco County, 1.5 mi north of the Whittemore Village limit, the deck of this 1950 structure has been covered with bituminous concrete. Curbs, posts, and substructure are in excellent condition with no popouts. SSB1 of 35-8-1, C2 (35011)



▲ Figure 8. Also on M 65 in Iosco County, 2.7 mi north of the Arenac County line, this 1950 structure has numerous small popouts on the deck, although the other surfaces are good. SSB1 of 35-4-1, C2 (35011)

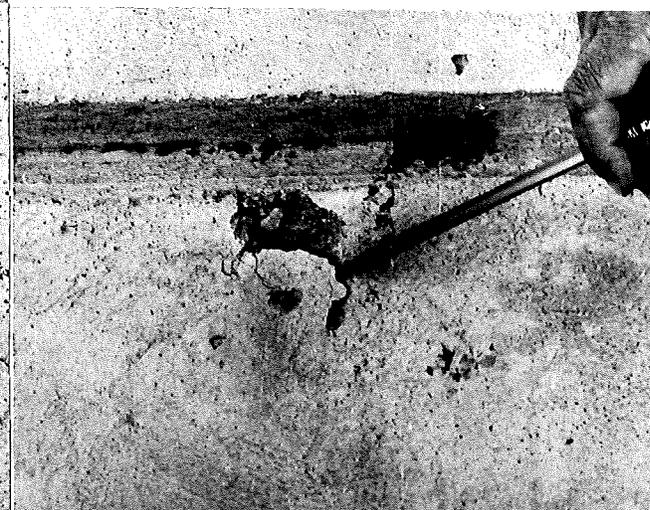


◀ Figure 9

This bridge, built in 1951, is on M 33 in Montmorency County, 3.8 mi south of the junction with M 32. The general view (Fig. 9) shows that the center deck lanes have been covered with bituminous concrete; however, a fairly heavy frequency of popouts and light scale are found on the exposed deck surface (Fig. 10). The substructure has light traces of popout action, as may be seen on the wingwall (Fig. 11). SSB1 of 60-5-1, C1 (60011)

◀ Figure 10

▶ Figure 11



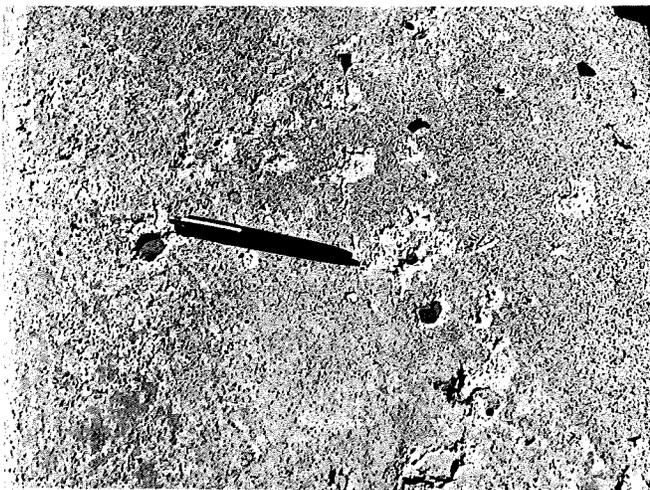


▲ Figure 12.



▲ Figure 13.

Located on south Cedar St. (US 27) in Lansing, this bridge was constructed in 1951. The deck surface has light to medium incidence of popouts. Walks at railing post locations show evidence of popouts and scale (Figs. 12 and 13). UUGX3 of 33-6-1 (33032).



▲ Figure 14.



▲ Figure 15.

Constructed in 1951, this structure is on South St. in Lansing. The top surfaces of the wingwalls have medium to heavy popouts (Fig. 14), but the sub-structure is generally free of this type of deterioration. The tar found on the deck surface (Fig. 15) was tracked over from the approach road surfaces. UB1 of 33-6-36, C1.



◀ Figure 16. Constructed in 1952 on M 65 in Alpena County, this structure is located about 7 mi south of the Presque Isle County line. The deck surface has medium to heavy incidence of popouts. The remaining surfaces are free of this defect. MB1 of 4-3-1, C1 (04012)



◀ Figure 17

This 1953 structure is located on US 16 (Grand River Ave.) in Lansing. The deck surface has light popouts (Figs. 17 and 18). Typical light scale on walks is shown in Fig. 19. Other surfaces are free of popouts. MB1 of 33-6-2, C1 (33081)



◀ Figure 18



◀ Figure 19

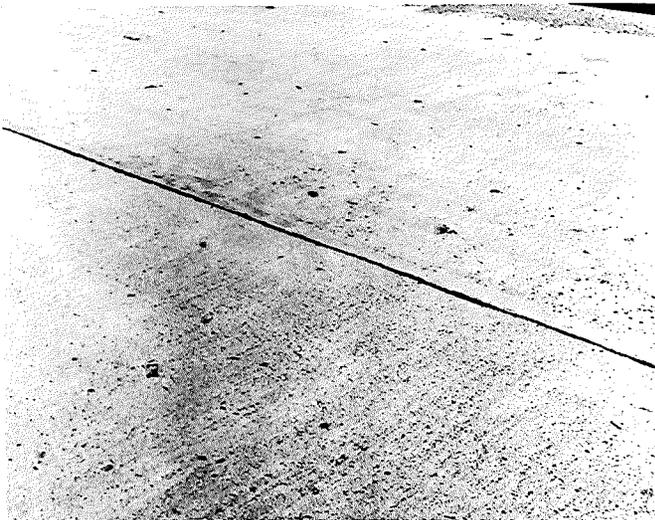


Figure 20

Figure 21

Constructed in 1953, this bridge is on Greenwood-Prescott Rd., 13.5 mi southeast of West Branch. Fig. 20 shows the degree of popouts on the deck surface. The break shown in Fig. 21 is along the south edge of the centerline longitudinal joint. CSB1 of 65-10-20, C1



This 1954 structure is on M 55, 3.9 mi east of M 65 in Iosco County. The deck surface has a moderate amount of popouts, but the curbs, railings, and substructure are free of this deterioration. FB1 of 35-5-1, C1R (35022)

Figure 22



Figure 23





Figure 24



Figure 25



Figure 26

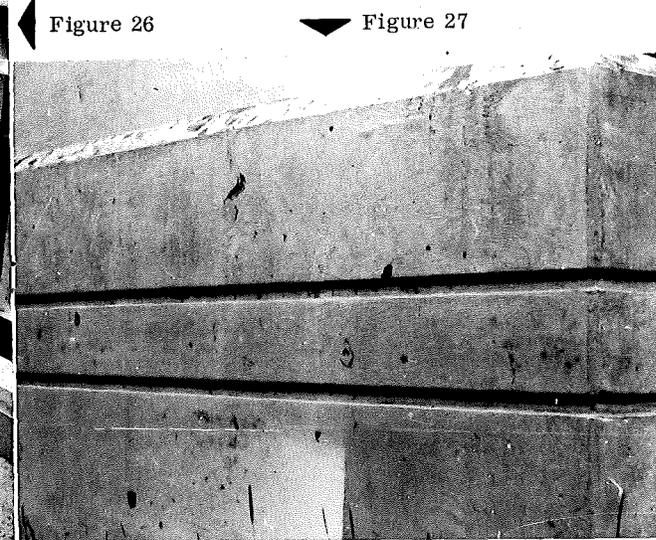


Figure 27

This 1954 structure is 2.2 mi directly east of the Onaway village limit on M 68 in Presque Isle County. Scattered small popouts are found on the deck (Fig. 24). Typical popouts of the safety curb may be seen in Fig. 25, at the southwest corner post; the cause of the severe deterioration of this post is unknown. Several other railing posts exhibit pronounced cracking around the base (Fig. 26). Fig. 27 illustrates the degree of popouts in the substructure. FB1 of 71-1-2, C1R (71021)



Figure 28. This 1954 structure is also located on M 68, 6.6 mi east of the Onaway village limit. A few small popouts are found on the deck surface, but other surfaces are free of this defect. FB1 of 71-5-2, C2R (71021).



Figure 29. Small, scattered popouts are present only on the deck of this 1956 structure, located on M 171 in Alcona County, 5.8 mi south of the junction with M 72. SSB2 of 1-9-1, C3R (01031)



Figure 30. Another 1956 Alcona structure on M 171, 5.3 mi south of the M 72 junction, has light popouts on the deck surface, heavier popouts on curbs and railing posts, and a substructure free of deterioration. SSB3 of 1-9-1, C1R (01031)



Figure 31. This 1957 bridge is on US 23 in Bay City, 0.3 mi east of the junction with M 47. All surfaces are in excellent condition, free of popouts. FGX2 of 9-15-8, C1U (09101)

This 1957 structure is in Gladwin County on M 30, 3.7 mi north of the junction with M 61. Although the general condition is good (Fig. 32) and the substructure excellent, scattered popouts are found on the deck and curbs. Cracked surface mortar is readily extracted from this concrete at popout locations (Fig. 33 before, Fig. 34 after). MB1 of 26-8-1, C2R (26032)

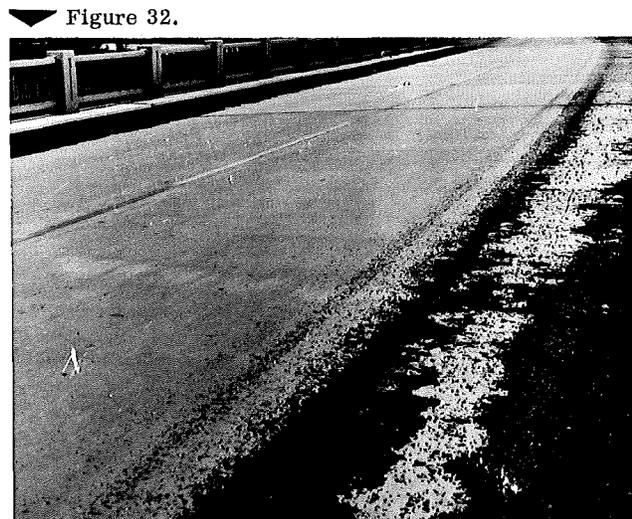


Figure 32.



Figure 33.



Figure 34.

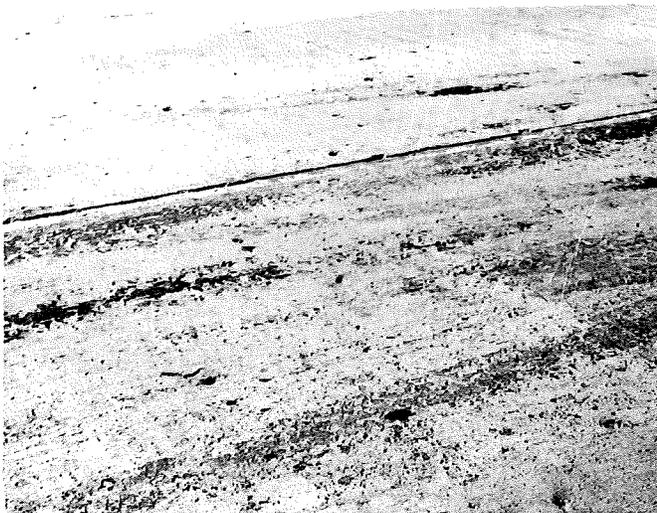


Figure 35

Figure 36

Another 1957 project, this structure is situated on M 33 in Cheboygan County, 0.2 mi south of the US 27 junction. The deck (Fig. 35) has some popouts, and curbs (Fig. 36) are in similar condition. One railing post displayed a notably large popout (Fig. 37). However, the substructure surfaces were in good condition. SSB1 of 16-3-1, C1R (16051)



Figure 37

This 1957 structure, located on Wurtsmith Air Force Base Road 6.6 mi west of Oscoda, has popouts on the deck surface only. B1 of 35-6-12, C1

This structure, in very good condition with no popouts on any surfaces, was built on an Alpena County road in Wilson Township in 1957. CSB1 of 4-8-21, C1

Figure 38



Figure 39





Figure 40

Figure 41

Popout action is occurring on the deck of this 1957 bridge on the new US 31 in Emmet County, part of the approach system for the Mackinac Bridge (Fig. 40). Figure 41 shows a deck popout, and Fig. 42 both a curb surface popout and the general deterioration at the curb base. The substructure was in very good condition. MB1 of 24-16-3, C1UN(24071)



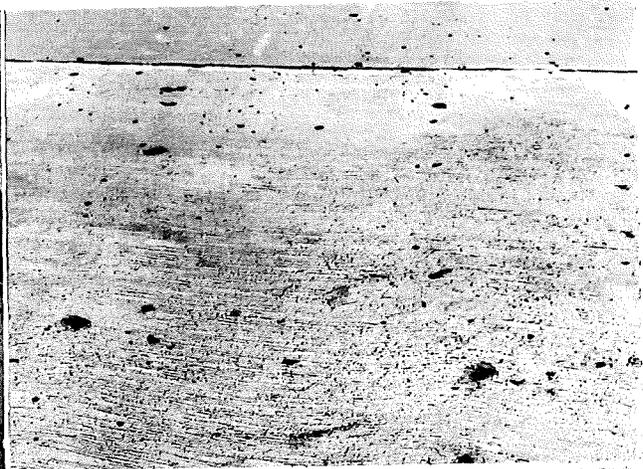
Figure 42



Figure 43. Nearby on US 31, another 1957 structure is in good condition, with only occasional popouts on the deck. MB2 of 24-16-3, C1 (24071)



▲ Figure 44



▲ Figure 45

▼ Figure 46

▶ Figure 47



▼ Figure 48

▼ Figure 49

▼ Figure 50



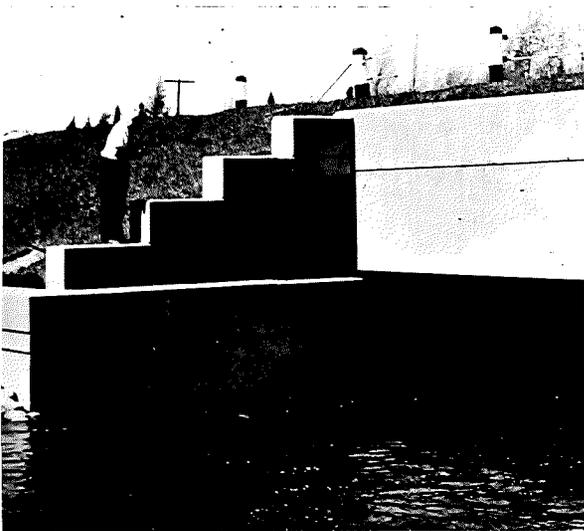
This 1957 overpass on US 27 in Emmett County is another part of the approach system of the Macknac Bridge. Frequent popouts are found on the deck (Figs. 44, 45, and 46); the deck surface (Fig. 47) is also the site of transverse cracking at the longitudinal joint. Severe curb deterioration is visible in Figs. 48 and 49. The substructure has less frequent popouts; the wingwall is shown in Fig. 50. MX1 of 24-16-3, C1UN (24071)



▲ Figure 51. This 1958 structure is located on an Antrim County road in Forest Twp. It is in excellent condition, free of any popouts. CSB1 of 5-7-22, C1.



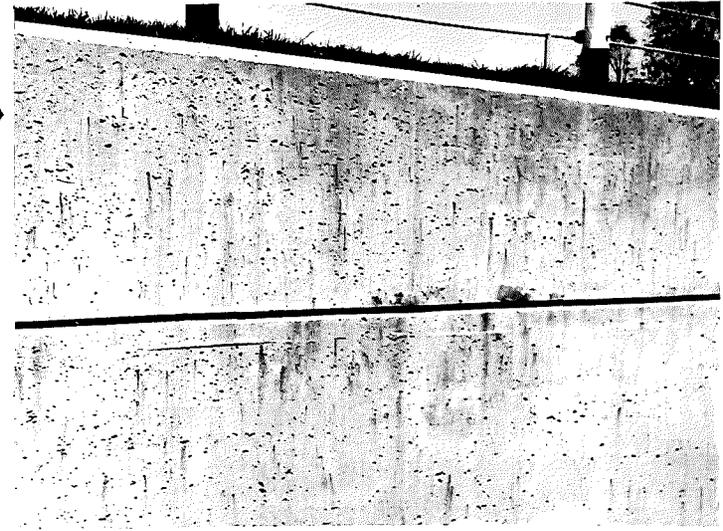
▲ Figure 52. Located on a Charlevoix County road in South Arm Twp., this bridge was built in 1958. The deck has been resurfaced with bituminous concrete, but all exposed surfaces have moderately frequent popouts. CSB1 of 15-13-24, C1R.



◀ Figure 53

Figure 54 ▶

This 1958 structure is on M68 in Cheboygan County, 5.8 mi west of the Presque Isle County line. No popouts were found on this structure, but numerous small air voids covered all the surfaces (Fig. 54). FB1 of 16-6-1, C2R (16023)





▲ Figure 55.

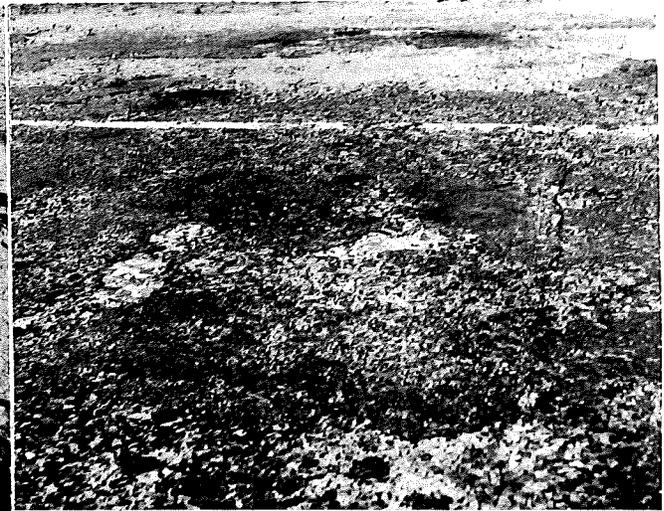


▲ Figure 56.

This 2.5 mi pavement project was built in 1927 on M 75 along the south shore of Walloon Lake in Charlevoix County. M 15-3, C6 (15071)



▲ Figure 57.

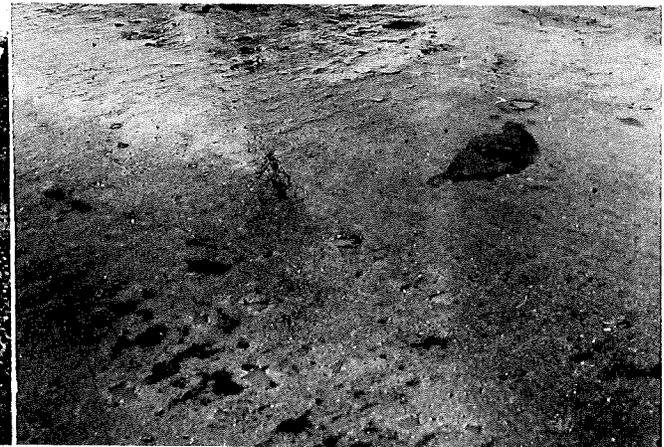


▲ Figure 58.

Another M 75 project, built in 1928, includes 1.4 mi at the north limit of Boyne City, and has deterioration similar to that above. M 15-3, C5 (15071)



▲ Figure 59. On M 25 from the Bay City limits east to the Tuscola County line, 7.9 mi of 1925 pavement has light scale but remains free of popouts. M 9-13, C1 (09042)



▲ Figure 60. On Henry St. in Bay City, 2.8 mi of M 47 was built in 1930, southeast and south from the C&O RR. Very light popouts occurred early in the project's life, with no aftereffect on the remainder of the surface. M 9-16, C1 (09012)



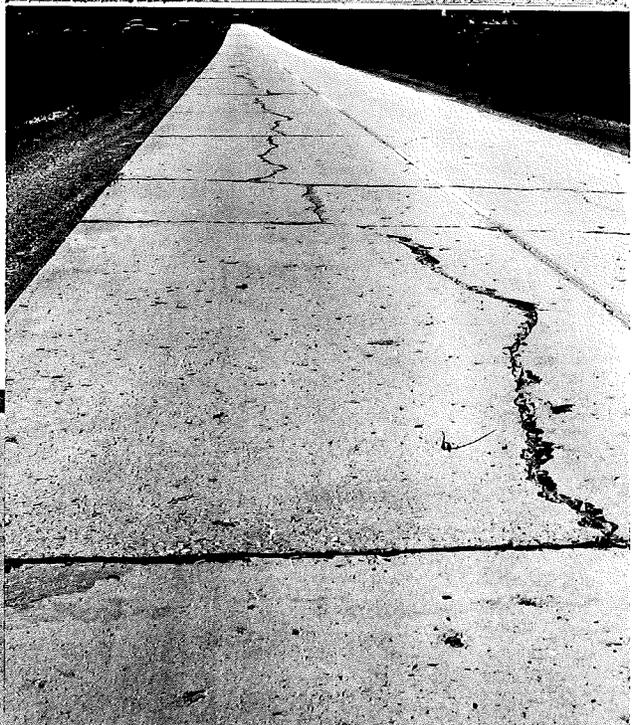
▲ Figure 61



Figure 62 ▶

In Alpena County on M 65, from the M32 junction north 1 mi, this 1930 project has moderate popouts (Figs. 61 and 62), and in one region, extensive longitudinal cracking (Fig. 63). M 4-12, C1 (04012)

Figure 63 ▶



◀ Figure 64. A 1931 project, 9.1 mi on US 23 from Omer to Augres in Arenac County, has moderate pop-out deterioration. F 6-12, C1 (06072-06073)



Figure 65

Figure 66

In Cheboygan County on US 27, from Mullett Lake northeast at the M 33 junction, this 4.2 mi 1931 project (Fig. 65) has moderately heavy popouts (Fig. 66) and areas of heavy scale (Fig. 67). F 16-19, C1 (16032)

Figure 67

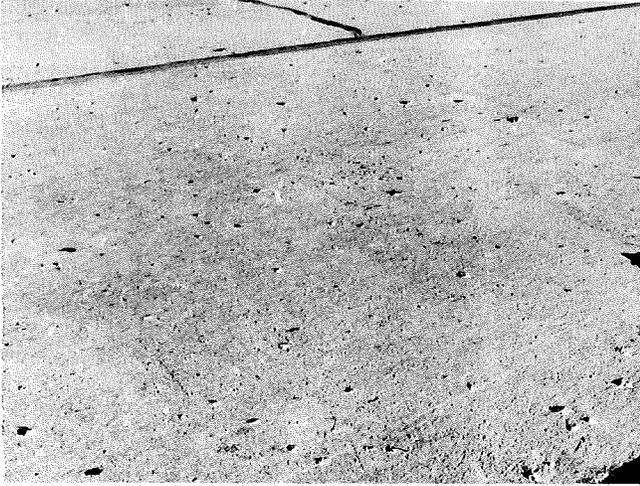
In Arenac County on US 23 in Omer, this 1947 project is 0.8 mi in length, and has fairly heavy frequency of popouts (left). The joint shown (right) is typical of structural deterioration on this pavement. F 6-1, C8 (06072).

Figure 68



Figure 69





▲ Figure 70



▲ Figure 71

Another 1947 project in Arenac County, 4.4 mi of M 65, from the US 23 junction north to the railroad in Twining, remains in fairly good condition, with mild deterioration as shown. M 6-27, C1 (06091)



▲ Figure 72



▲ Figure 73

This 1948 project in Iosco County, also on US 23, includes 0.6 mi from the M 171 junction southwest. General surface and joint conditions are illustrated. F 35-3, C9 (35032)



▲ Figure 74



▲ Figure 75

This 1948 project comprises 0.6 mi of US 23 south from the Alpena south city limit, and features moderate popouts. M 4-4, C7 (04031)



▲ Figure 76



▲ Figure 77

On US 27 in Cheboygan County, this 6.5 mi 1949 project runs south from the south limit of Topinabee, with moderately heavy popouts throughout. F 16-29, C3 (16032)



▲ Figure 78



▲ Figure 79

Another 1949 Cheboygan County project on US 27, this 0.5 mi pavement in Wolverine has moderately frequent popouts. Fig. 79 shows a longitudinal crack from shoulder to pavement centerline. F 16-12, C3 (16031)



▲ Figure 80. In Arenac County at Standish, this 1950 pavement extends from the US 23 junction west for 0.4 mi. Popouts appear in fairly heavy concentration throughout the project. M 6-16, C1 (06021)



Figure 81. This 1952 project includes 0.6 mi of M 65, from the south limit of Whittemore north, with the moderate concentration of popouts shown. M 35-14, C6 (35011)



Figure 82

Figure 83

On US 131 at the junction with M 88 in Antrim County, this 0.2 mi 1952 project has moderate to heavy popouts and rather heavy scale. M 5-7, C5 (05071)

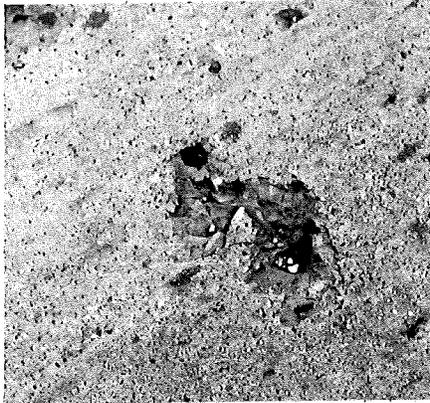


Figure 84



Figure 85

Located on US 23 — US 27 in Cheboygan, this 1956 project is 1.2 mi long. The entire surface is covered with heavy popouts. Note the longitudinal crack in Fig. 85. F 16-3, C2 (16033)



▲ Figure 86



▲ Figure 87



▲ Figure 88

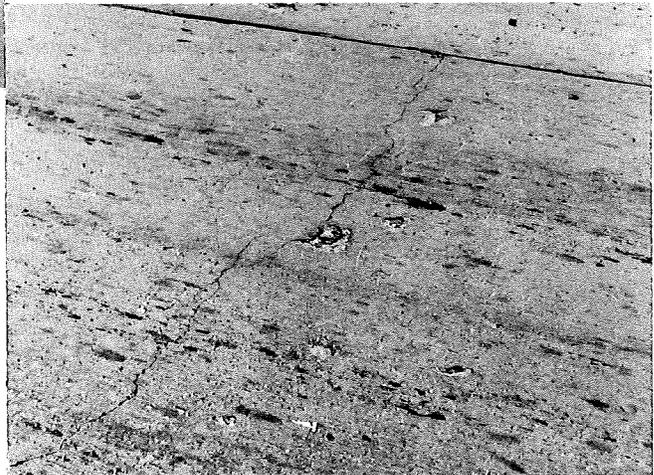


◀ Figure 89

On a south approach to the Mackinac Straits Bridge on US 31, this 1.4-mi project was built in 1957. The surface is marked with moderately heavy popouts (Fig. 89), details of which are shown in Figs. 86, 87, and 88. F 24071, C2

▶ Figure 90

In 1958, this 1.4 mi project was built in Arenac County, composing the intersection of M 76 and US 23 in Standish. The M 76 portion has fairly frequent popouts (Figs. 90 and 91), and large ones are scattered over the entire US 23 surface (Figs. 92 and 93). M 76: M 06011, C1; US 23: F 06072, C1



▼ Figure 91

▼ Figure 92

▼ Figure 93

