Widening and Resurfacing Highways with Concrete

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THIS paper covers a review of over 100 miles of concrete resurfacing work done in Iowa during the period 1931 through 1954 with a condition report on some of the oldest projects. It includes a brief description of the slab section and the reinforcing steel of both the original pavement and the resurfacing on some forty-five projects.

It suggests that the present condition and the service records of these projects together with the performance under heavy traffic of those at least twenty years old indicate the practicality of concrete resurfacing for modernizing old pavements.

● IOWA has found that the ever increasing volume, heavier loads, and higher speeds of modern traffic make necessary some revision of roads which were constructed to standards of twenty five or more years ago. Official figures show that in 1930 Iowa had 708,138 passenger cars and 73,417 commercial vehicles registered in the state. These figures had increased in 1953 to 913,148 and 211,432 respectively, showing an increase of 29 percent in passenger cars and 188 percent in commercial vehicles.

Fuel used on the highways has increased from 334 million gallons in 1930 to over 807 million gallons in 1953, or from 430 gallons per year for each vehicle registered to about 720 gallons per vehicle, clearly indicating the fact that we are all using our cars and the highways more each year.

There are occasional sections where sight distance and alignment are inadequate for traffic speeds of today, but more often widening is required and in many cases strengthening is needed to make the pavement meet the requirements of current traffic needs.

While it is true that the largest part of the mileage involved in this study of portland cement concrete resurfacing of old concrete pavement has been post-war construction, a number of comparatively short projects were built in the pre-war era and we feel that they are most important as evidence of the performance record. We have arbitrarily divided the projects into 5 year periods from 1930 through 1950 for the purpose of design comparison, and in order not to go into unnecessary detail on each individual one.

A brief description of the typical design details and present condition of the projects in each period are given in the following paragraphs.

In the early period from 1931 to 1935, much of the work was done in urban areas on streets that had averaged 18 years of service. (Rural paving mileage prior to the beginning of the big paving program in 1928 was low). If the old street surface was of material other than concrete, it was removed to the concrete base which varied from four to six inches in thickness. The new widening was built from 10 to 13 inches thick and resurfacing from 5 to 6 inches.

In every case, mesh reinforcement (44 lb.) was used and usually $\frac{5}{8}$ inch round tie bars were placed across the longitudinal joints. Expansion joints were spaced 61.5 ft. apart and an assembly of $\frac{5}{8}$ in. round dowel bars spaced at 2 ft. centers was used as a load transfer device. No contraction joints were provided.

These projects are all in good condition today, but one located on US 20 in South Sioux City shows some surface spalling which was caused by placing the wire mesh too near the surface.

In the period from 1935 to 1940 all the resurfacing was done on city streets originally surfaced with concrete, asphalt or wood block and from 20 to 25 years old. Widening of 10 in. thickness and resurfacing varying from 4 to 6 in. was used. Some experiments were made in jointing practice. Expansion joints were placed from a minimum of 35 ft. to a maximum of 118 ft. apart and contraction

Figure 1. Short sight distance, narrow width and appearance of the pavement before resurfacing.

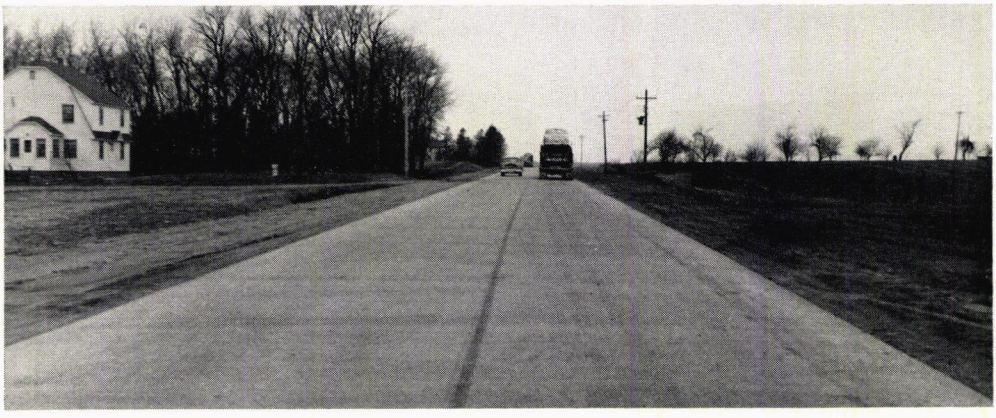

Figure 2. After resurfacing.

TABLE 1

Year Widened	Year Originally Built	Miles*		Pavement Width		Traffic Count (1954)	Reinforced	Thickness in Inches		Condition
		Urban	Rural	Old	New			Widen.	Resurf.	
1931–35	1913–18	4.8	2.7	16–40	20–40	2000–5400	Yes	10–13	5–6	Good to Excellent
1935–40	1912	7.3		18–54	18–55	2400–7000	Yes	10	4–6	Good to Excellent
1940–45	1915		.4	16	45	1600	No	9	6	Excellent
1945–50	1927–28	4.8	23.5	18–60	24–72	3100–23,600	Yes	8–10	6–8	Excellent
1951	1925–33	3.7	17.6	18–24	24–70	2200–13,000	Yes	8–10	6–8	Excellent
1952	1919–31	2.5	32.5	18–20	24–49	3000–10,700	Yes	8–10	5–6	Excellent
1954	1928	5.5		18	24	3300	Yes	10	6	Excellent
Totals		28.6	76.7							

* *Note:* Miles represent yardage expressed in equivalent 22 feet width.

joints were constructed at 25 to 35 ft. intervals. Wire mesh reinforcement was again used in every project with a minimum of 30 lb. and a maximum of 58 lb.

The project constructed in Fairfield in 1937 had expansion joints every 35 ft. in a 4 in. thickness of resurfacing and a dowel assembly not carefully placed parallel to the surface. It began to show spalling at the end of the dowel bars in some places after about 13 years of service and it was necessary to do some patching at the joints. No other trouble was encountered and all of these projects are in good to excellent condition today.

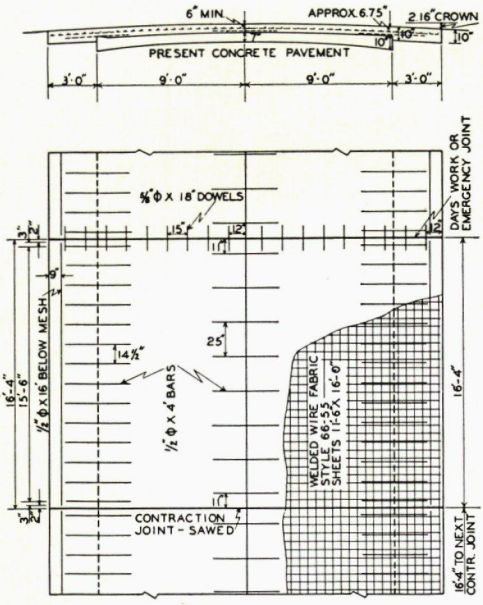

Figure 3. Current design of resurfacing.

In the war years, 1940 to 1945, only one small project was built (in 1942) involving 5250 sq. yd. on Iowa 80 from the east gate of the Iowa Ordnance Plant to the west corporation limits of Burlington. Here an old concrete pavement of 6–7½–6 cross section, 16 ft. wide, constructed in 1915 was resurfaced with 6 in. of concrete and widened to 45 ft. with a 9 in. thickness. This is the only project studied which was unreinforced. One-half in. by 4 ft. tie-bars at 4 ft. centers were used over the edge of the old slab into the widening (none at the longitudinal center joint). Expansion joints were spaced 120 ft. apart and contraction joints at 30 ft. intervals.

Current traffic count on this road shows only about 1600 vehicles per day, but at the height of activity at the ordnance plant during the war there was over 5000. After 12 years of service this road is in excellent condition.

The next division, 1945 to 1950, takes us into the post-war period and the time when salvaging operations must be initiated on a

Figure 4. Machine developed by C. L. Gleason, construction engineer, Iowa State Highway Commission, to remove all integral curb before resurfacing.

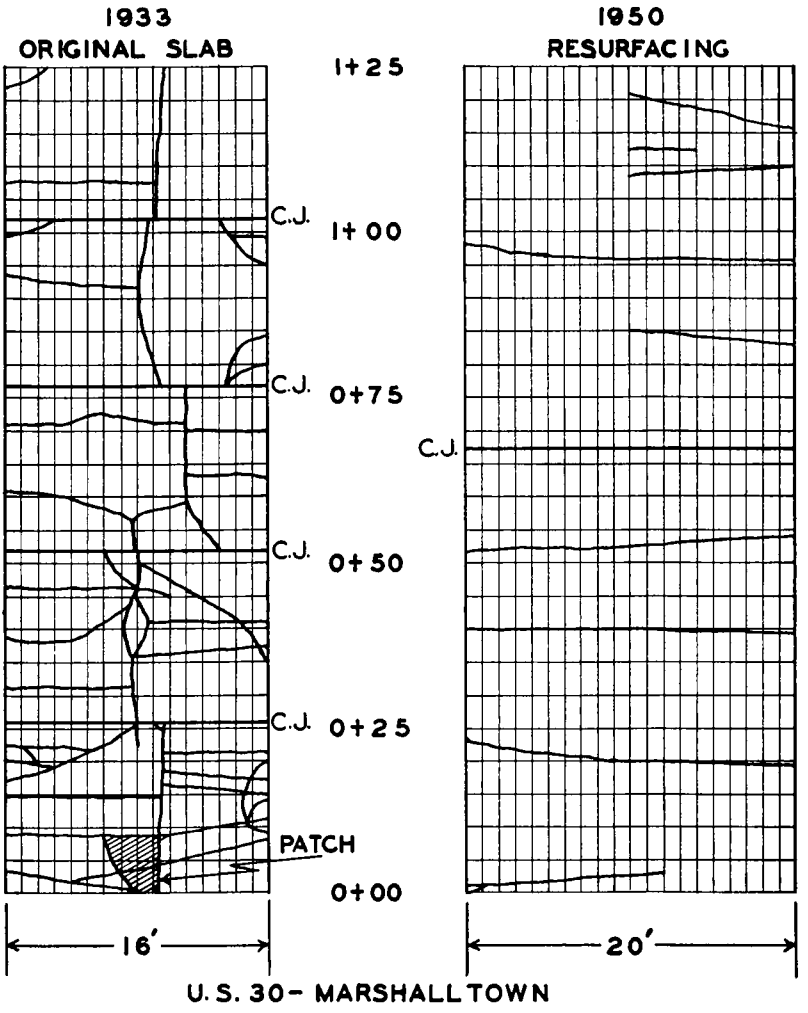

Figure 5. Typical condition survey record showing cracks and joints in the old slab at the time of resurfacing in 1933 and a similar survey of the resurfacing 17 years later.

substantial mileage of our rural concrete highways. Having observed the uniformly good service record of previous resurfacing projects, the Iowa State Highway Commission standardized the design in this period to one which they have used with little change to the present time.

Widening strips 10 in. thick are placed integrally with a 6 in. nominal thickness of resurfacing. Wire mesh weighing 49 lb. per 100 sq. ft. is used in the resurfacing with ½ in. by 4 ft. transverse bars spaced at 14½ in. over the edge of the old slab. A ½ in. longitudinal bar is placed 9 in. in from the outside edge of the widening and ½ in. by 4 ft. tie-bars are spaced at 25 in. centers over the centerline joint.

Contraction joints are spaced at 16 ft. 4 in. with no steel through the joint. With the exception of every fifth joint they are sawed 1½ in. deep, then filled with a special bituminous filler. A premoulded bituminous strip ⅛ in. by 2½ in. is placed every fifth joint for control of cracking until sawing is accomplished. Expansion joints are used only at bridges and intersections and a ⅝ in. dowel assembly is used as a load transfer device.

There have been minor variations in the

steel used during the period, but this is basically the design used from 1948 through 1954 and since all projects so constructed are performing well and are in excellent condition, no immediate change is probable. The sawed contraction joints are a recent innovation, replacing joints formed with a bituminous parting strip and which in some instances was moved from a plane normal to the paving surface by the finishing operation causing subsequent trouble with spalling at these inclined joints.

In general, preparation of the old slab for resurfacing involved only removal of loose concrete and knocking off integral curbs. To expedite curb removal, a machine was developed by Mr. C. L. Gleason, Construction Engineer, Iowa State Highway Commission. This machine, operated by compressed air, knocks off old curb at a rate up to 600 ft. an hour at a minimum cost.

Construction practice involved placing the widening strip integrally with the resurfacing. Where grade changes or re-alignment made necessary the construction of new pavement, a standard 10-9-10 section was laid using the same equipment and material as for the resurfacing, enabling the contractor to proceed in a continuous operation.

Mix proportions were the same as for paving. A typical mix design required 602 lb. of cement; 1391 lb. of fine aggregate; 1701 lb. of coarse aggregate with a water-cement ratio of 4.85 gallons of water per bag of cement. This is an air-entraining mix with specification limits of 3 to 5 percent air. Average modulus of rupture strengths obtained were 700 psi. (Average of 67 beams tested at 7 days, three separate paving projects.)

It is interesting to note that from the very first project studied right up to the last, no attempt was made to secure bond between the resurfacing and the old slab. In fact, in the early period, subgrade paper was used to insure freedom from bonding. However, from 1935 up to the present time, in the thicknesses observed in this report, no effort was made to either insure bond or to break it and there is no difference in the performance of the resurfacing. The cracks and defects in the old slab are not reflected in the new as shown by detailed condition surveys of both old and new slabs.

Further study might well be worthwhile to determine at what point deterioration of the old slab will be detrimental to the service life of the resurfacing. Some of the old roads were built with a limestone coarse aggregate subsequently found to be unsound and no longer permitted by Iowa specifications. These roads showed considerable growth as evidenced by many "blow-ups" before resurfacing. Since resurfacing some 21 miles on US 30 in 1949 no further "blow-ups" have occurred.

A general observation that may be of increasing importance as quality aggregates become scarcer and more costly is the fact that marginal aggregate has given better service in resurfacing than in original pavement laid directly on earth. This is well illustrated by the Marshalltown resurfacing on US 30 now 21 years old, and by a four block project on Grand Avenue in Ames which is 26 years old. Both of these projects were made with aggregate now considered unacceptable but neither has ever displayed the disintegration characteristic of the same aggregate when used in paving directly on the ground. Possibly this can be attributed to the more constant moisture content in the resurfacing slabs.

Further experimentation was indicated and late in October 1954 a research project, recommended by the Iowa Highway Research Board and sponsored and financed by the Iowa State Highway Commission, was constructed to study the behavior of thin concrete resurfacing bonded to structurally sound concrete pavement.

Widening of 2 ft. on each side, 10 in. thick, and resurfacing of 1, 2, and 3 in. nominal thicknesses, some with mesh reinforcing, and some without, was constructed on 1535 ft. of old (1921 construction) concrete pavement located on US 34 just west of West Burlington.

CONCLUSION

Bonding of the 4 to 6 in. resurfacing to the old pavement, whether it existed or not, did not appear to be a factor of any importance in the performance of the resurfacing.

A comparison of the one project built in 1942 without reinforcement and the other projects with reinforcement leaves a question as to the value of distributed reinforcement in resurfacing of the thicknesses reported in this paper.

With the exception of the few weaknesses found to be a result of careless construction practices all projects studied have proven eminently satisfactory.