

roads bridges transit technology news

Local Transportation Information Center
Iowa State University Engineering Extension Service

November 1986

Strengthening of highway bridges by post-tensioning

By F. Wayne Klaiber, professor of civil engineering, manager Bridge Engineering Center, Iowa State University; and Vernon J. Marks, research engineer, Iowa Department of Transportation

Iowa has the same problem that confronts numerous other states: many simple-span, steel beam composite, concrete slab bridges built between 1940 and 1960 are not in complete compliance with today's bridge standards. In Iowa alone, approximately 400 bridges of this type require "strengthening" to meet current standards. More specifically, the live load-carrying capacity of the steel stringers of these bridges must be increased. This need for additional strength is the result of increases in legal load limits, changes in AASHTO specifications that mean exterior stringers carry a greater load, and added weight from resurfacing with dense concrete overlay. The alternative to strengthening these bridges is to post load restrictions. As these bridges are on low-traffic secondary roadways as well as on relatively high volume traffic primary roadways, there is a considerable amount of truck traffic involved. Those trucks over the posted load limit would be required to take alternate routes, thus traveling additional miles. If one assumes the posting of a given bridge affects 50 trucks per day and each truck has to detour 10 miles out of route at a rate of \$1 per mile, the posting of one bridge would cost the trucking industry \$182,500 per year. Given these assumptions, strengthening

the bridges in question instead of posting them could be extremely cost-effective.

In an attempt to find a solution to this problem, a feasibility study was undertaken by the Engineering Research Institute of Iowa State University with funding from the Highway Division of the Iowa DOT. Among the numerous potential solutions to the problem, post-tensioning of the steel stringers exhibited the most promise. This idea was originally suggested by John Harkin, bridge rating engineer, Bridge Design Section, Iowa DOT.

To determine the distribution characteristics of the post-tensioning force, a half scale model bridge (26' x 15'-8 $\frac{3}{8}$ "), shown in photo 1, was fabricated and tested. This testing showed that when only the exterior beams are post-tensioned, approximately two-thirds of the post-tensioning force (for a four-beam bridge) affects the exterior beam.

Therefore, for adequate post-tensioning, more force must be applied in order to compensate for post-tensioning distributed to the remainder of the bridge. Obviously the amount of post-tensioning force affecting the exterior beams is a function of beam spacing, beam size, span length, etc., and thus the $\frac{2}{3}$ fraction will differ for various bridges.

Based on the results of the feasibility study, a second project, also sponsored by the Highway Division of the Iowa DOT, was undertaken by ISU. In this phase, two existing bridges were strengthened using the post-tensioning scheme developed in phase I. One of the bridges (bridge 1: 52' x 30') was twice the size of the prototype tested in the laboratory. The other bridge (bridge 2: 72' x 30', 45° skewed) is shown in photo 2. Both of the bridges were instrumented and tested. After a period of approximately two years, during which time the bridges were

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The preparation of this newsletter was financed through the Technology Transfer (T2) Program. The T2 Program is a nationwide effort financed jointly by the Federal Highway Administration and individual State Departments of Transportation. Its purpose is to translate into understandable terms the latest state-of-the-art technologies in the areas of roads, bridges, and public transportation, to local and county highway and transportation personnel.

The T2 Center at Iowa State University is sponsored by the Iowa Department of Transportation and provides information and counsel to the municipalities and counties in Iowa. This newsletter is

designed to keep you informed about new publications, techniques, and training opportunities that may be helpful to you and your community. Individuals wishing to receive future copies of this newsletter at no cost may send their requests to: John Moody, Local Transportation Information Center, Engineering Extension, Iowa State University, Ames, Iowa 50011.

The opinions, findings, or recommendations expressed here are those of the Local Transportation Information Center and do not necessarily reflect the views of the Federal Highway Administration or the Iowa Department of Transportation.

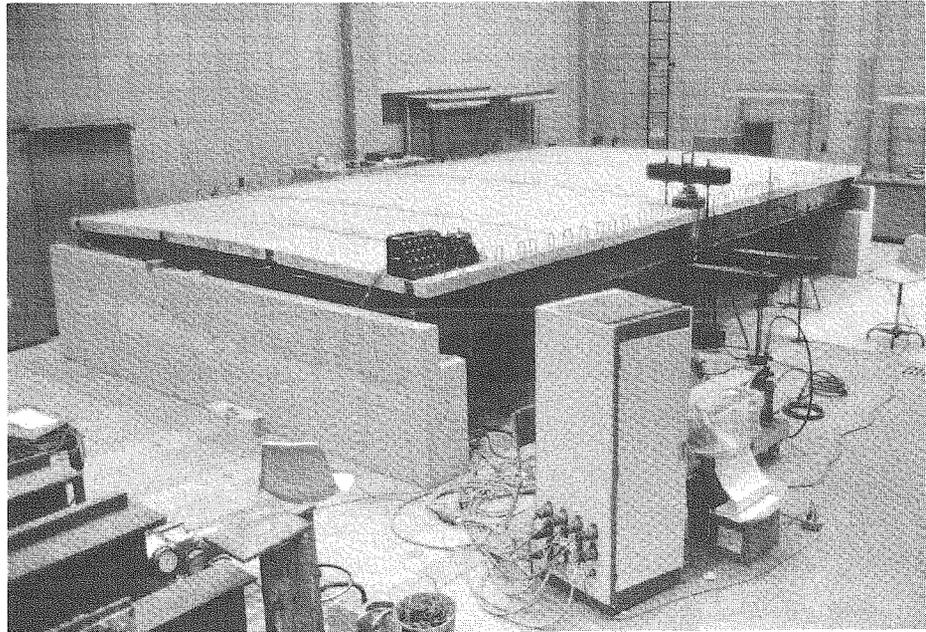
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periodically inspected, the bridges were retested. Their behavior was found to be essentially the same as the model bridge previously tested with one exception. In the field, both of the bridges (assumed to be simple spans) exhibited a considerable amount of end restraint due primarily to abutment restraint of the beams.

From the results of the testing plus a finite element analysis, a simplified design methodology was developed. This design procedure along with design examples was published in a design manual making the procedure readily accessible to practicing engineers.

To the authors' knowledge, the procedure has been used by several states in addition to Iowa. This past February (1986), two bridges (50' x 30') were strengthened using the post-tensioning system at a cost of \$13,400 per bridge. If strengthening extends the service life of the bridge 20 years, thereby attaining the expected 50-year service life, a savings of 40 percent of the cost of replacing that bridge could be realized. At today's construction costs, the savings would be about \$28,000 on a 50' x 30' bridge costing \$70,000. Larger savings would be realized on longer spans, as replacement costs of the larger bridges would increase considerably faster than strengthening costs. Thus post-tensioning strengthening creates savings in two different ways—avoids costly detours and adds service life to existing bridges.

Presently a third Iowa DOT (Highway Division) sponsored bridge strengthening research project is under way at ISU, involving the strengthening by post-tensioning of continuous bridges. A one-third scale model 3-span bridge (42' x 8'-8") has been constructed in the laboratory and testing is currently in progress.



Half-scale model bridge

Tips for preparing for winter

An effective winter snow control program requires year-round work and planning. To make sure your town's snow control operation is comprehensive and well planned, refer to this checklist.

Prewinter planning

- Plan plowing routes to bring trucks back to storage facilities when they are almost empty of deicing material. This saves time and fuel. Keep plowing routes short so they can be completed in two hours or less at a maximum speed of 25 miles per hour.
- Plan to keep routes for fire and other emergency vehicles plowed at all times, no matter what the weather.

- Have employees make trial runs of their routes before winter to familiarize themselves with routes, road conditions, obstacles, and problem areas. Remember that road conditions change from year to year and obstacles may be present now that were not there in the past.
- Plan fall meetings to familiarize road crews with their winter duties and all routes in case someone becomes ill and another crew member must take over the route.
- During trial runs, pinpoint drains and waterways that must be opened after every storm. Mark other structures that will be hidden from a plow, including fire hydrants, guide rails, drop inlets, catch basins, and curbing ends.

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U.S. Department
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**Federal Highway
Administration**



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- Train operators thoroughly in the use of their equipment. This will ensure that operators are more effective and that equipment will last longer and cost less to maintain.
- Check all equipment, including wing and plow hydraulic systems, repairing, replacing, and painting where necessary. Inspect the condition of moldboards and cutting edges on all snowplows. Order an adequate stock of parts for plows. Inspect snowplow hoists and underbody blades. Check air and hydraulic hoses and other critical parts of power units.
- Mount, load, and test all spreaders. Make necessary repairs to spreaders and order critical parts. Calibrate all spreaders and place a calibration card on the visor or in the compartment of each truck. Keep copies of all calibration cards on file. Make sure all personnel are familiar with spreader controls, whether automatic or manual.
- Inventory and order all equipment parts in the fall so they will be on hand when needed. It is difficult to obtain parts with a blizzard in progress.
- By the beginning of winter, have stockpiled one-half to three-fourths of the amount of deicing material you expect to use in the winter. Reserve piles and "self-help" barrels for motorists to use at trouble spots are also good to have on hand.
- Properly store salt and other chloride components that may harm the environment and endanger the health of local residents.
- Let the media, police, fire, and other officials know about your winter snow control plans. Provide citizens with a telephone number where they can reach the road crew in an emergency.
- Consider contracting with a private weather forecasting firm that gives localized coverage for your area.

Winter operations

As soon as a snow warning is received, get equipment ready and onto the location to start the snow removal process. You'll save time and prevent traffic tie-ups.

- Make sure plows are set at a right angle both vertically and transversely. If they are set at the wrong angles, plows can require more effort to push, resulting in greater fuel consumption.
- If you are only plowing, your truck should be no more than one-half loaded with deicer and the truck bed should never be raised.
- To save fuel, use the optimum gear ratio when plowing.
- Begin deicing as soon as snow starts to accumulate to keep snow and ice from bonding to the pavement. When spreading deicing material on two-lane roads, make sure the truck straddles the center line of the road. This saves time and fuel because the spreader has to make only one pass on these roads.
- Take advantage of nature when deicing. Let the wind help to spread salt and abrasives over the road. On elevated curves, let gravity work by spreading on the high part of the curve.
- To determine when to reapply deicer to the road, watch the tires of cars traveling along the road. If snow falls directly behind the tires, it is time to reapply salt or abrasives. If snow fans out under the tires, however, the deicer is still working.
- When spreading deicer or plowing and spreading simultaneously, never raise the truck bed higher than the

top of the cab. Always stop the truck, raise the bed, shift the material to the spreader, and then lower the bed.

- Consider continuous plowing of both roads and road shoulders during a snowstorm. That way, if another storm occurs within a few days, only fresh snow has to be plowed.
 - Once the snow has stopped and plowing is finished, return to areas where drifting has occurred. Take two trucks on tandem and clear out the excess snow before it has time to harden. It is easier to push the drifts away from the road or cut down drifts when the snow is still fresh.
 - Clear drains and catch basins to allow melting snow and ice to run off. Clear snow from barrier walls and traffic dividers to reduce later melting and refreezing of snow and to increase driver visibility. Also, plow and haul snow away from sharp corners and bends to increase visibility.
 - Remove the windrows on the sides of bridges to prevent drifting. If windrows are allowed to remain, available roadway will be reduced and snow will later melt and form ice.
 - Clear snow from raised medians to prevent drifting. If drifting does require roads to be closed, use a front end loader to shove banks back as
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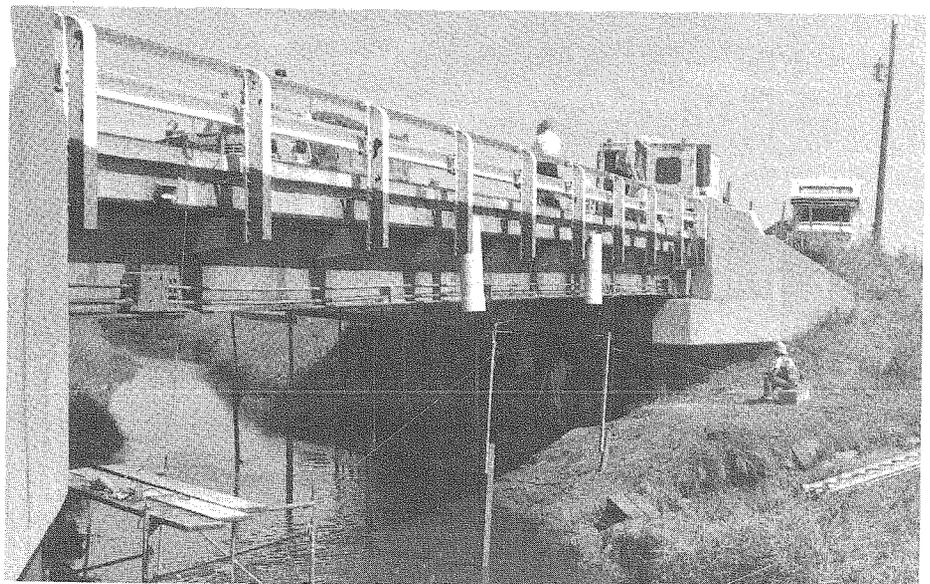


Photo 2: Strengthened bridge 2. (Insert: Close-up of post-tensioning bracket and tendon in position.)

(continued from page 3)

far from the road as possible to keep them from building up near road shoulders.

- After returning to the garage, check the trucks, including wipers, lights, oil, antifreeze, blades, and hydraulic systems. Make sure to fuel and load trucks so they are ready to go at the next sign of snow.
- Use fencing to prevent drifts and reduce the need for snow and ice control.
- Preventive maintenance of equipment should be performed throughout the winter months after every 100 hours of service. This will add years to the life of the equipment and keep "down-time" to a minimum.

From *Transportation Information Exchange News*, St. Michael's College, Vt.

Correction on purchasing from the Iowa DOT

In the September issue of *Technology News* there was an article outlining how to purchase from the Iowa DOT. The phone number published was not correct. The correct number is 1-515-239-1310.

State Highway Safety Office moves to Department of Public Safety

As part of state government re-organization, the Governor's Highway Safety Office has been moved to the Department of Public Safety. It is now called the Governor's Traffic Safety Bureau (GTSB). The general phone number is still 1-515-281-3907. The new address for GTSB staff is:

Governor's Traffic Safety Bureau
Department of Public Safety
Wallace State Office Building
Des Moines, Iowa 50319

Winter driving tips

Before setting out on winter roads, monitor weather reports. If you hear storm warnings while driving, get off the road, if possible, before a winter storm strikes. If travel is necessary in threatening weather, make sure your vehicle is in good mechanical condition with good winter tires and a full gas tank. Continue to listen for updated radio weather reports and adjust your speed for road conditions.

Mini survival kit items for your vehicle

- Steel shovel or hoe
- Wool blankets or a sleeping bag
- Candles or cans of Sterno™
- Matches
- Metal coffee can to melt snow
- Plastic garbage bags or sheet of plastic for body wrap

Extra items for a more complete survival kit

- Extra warm clothing, gloves, headgear, and footwear
- Nonperishable food
- Fuses
- Flashlight and warning flares
- Extra coffee cans for wastes
- Sack of dry sand, poultry grit or "kitty litter"
- Box of tissues or paper towels
- Transistor radio
- Booster cables

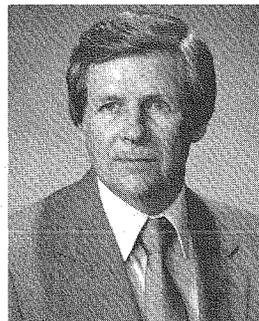
- Tow chain
- Hand ax
- Citizen band radio
- Ice scraper and snow brush

If you become stranded in a winter storm

- Don't panic. Work slowly to avoid overexertion and heart attacks.
- Stay in your vehicle; if you leave it you may get lost. It is your best protection and hope for discovery.
- Keep fresh air circulating. To avoid carbon monoxide build-up in vehicle, clear snow from exhaust pipe and open a downwind window for ventilation. Run the motor and heater only when necessary.
- Keep active. Move limbs vigorously to help circulation, relieve tense muscles, and help keep you awake.
- Turn on dome light. It will help you watch others in the car and make the car more visible to passersby.
- Don't allow all passengers to sleep at the same time.

For more winter driving tips and precautions, contact Gus Horn, safety program planner, Iowa Department of Transportation, Lucas State Office Building, Des Moines, Iowa 50319; phone 1-515-281-5012.

Jordison named Asphalt Paving Association of Iowa (APAI) executive vice president



Executive vice president of the APAI—
Donald R. Jordison

Donald Jordison was recently named executive vice president of the Asphalt Paving Association of Iowa

(APAI). Before joining APAI, he was with the Iowa DOT, as a bituminous construction field engineer for the state. Jordison has assisted counties and cities in their selection and use of asphalt materials, conducted training programs, administered Federal Highway Safety programs and designed urban streets and freeways.

Jordison succeeds John C. McClelland, Jr., who is retiring. He assumed his new responsibilities July 1, 1986.

References relevant in tort liability matters

By R. L. Carstens, professor
of civil engineering

The writer has been asked to recommend publications that would be most appropriate in the libraries of engineers and other individuals interested in tort liability related to highways. Conventional wisdom suggests that such a list should be headed by the *Manual on Uniform Traffic Control Devices (MUTCD)* and should include virtually all the policies of the American Association of State Highway and Transportation Officials (AASHTO) or its predecessor the American Association of State Highway Officials (AASHTO). Some people involved in tort liability also make use of the several handbooks of the Institute of Transportation Engineers.

Depending upon the specifics of a particular case, one or more of the publications mentioned above may be useful. However, except for the *MUTCD*, it is the writer's experience that the real issues of a case are seldom addressed meaningfully by written material. Generally, the exper-

ience and knowledge of a witness is much more relevant than any written policy. For example, in the writer's involvement with more than 100 cases alleging highway design deficiencies, there was only one case where the designer actually deviated from written design guidelines. (This case concerned the configuration of an interchange ramp.) In all other cases, the design features at issue conformed with the applicable standards or guidelines in effect at the time a design was formulated. These cases were resolved by considerations other than whether a design conformed with a written policy.

Most states permit a comparison of design features with the standards in effect at the time a design is approved. Under these circumstances, it is absurd to see an "expert" comparing a road designed in the 1930s with design policies set forth in the 1984 AASHTO green book. Since so many highways exist as they were designed 40 years ago

or more, perhaps the most useful reference from AASHTO is *A Policy on Design Standards*, dated 1940. This booklet is suggested for inclusion in your library. It includes geometric design standards for primary highways adopted by AASHTO in May, 1941, and for secondary and feeder roads, adopted August 1, 1945.

In respect to legal issues involving use of traffic control devices, one must make use of the *MUTCD*. However, considerations of engineering judgment should settle most such cases since use of any traffic control device is made "on the basis of an engineering study of the location" since the *MUTCD* contains so few mandates for use of a device.

It is apparent that no single list of relevant references would be appropriate unless it were too extensive to be practicable.

Notice to traffic engineers

The extension of daylight savings time to include the first three weeks in April will cause thousands of traffic signals to be out of synch one hour for this three week period.

Actions to correct this change vary depending on the type and manufacturer's model. In most cases it

involves replacing a ROM chip with a new chip. In some cases it can be accomplished in the field by an electrician, in others it requires a shop change.

If you use preprogrammed internal calendar clock controllers, you will need to contact your manufacturer.

Although April seems far away, it may take some time to receive the new controllers.

In many cases, you can use the Traffic Engineering Assistance Program (TEAP) federal funds to accomplish this change.

New computer information from the FHWA

The following new developments have just been released by FHWA

1. TRANSYT-7F Data Input Manager (DIM)
2. TRANSYT-7F Self Study Guide
3. Expanded version of TRANSYT-7F (microcomputer version)

4. NETSIM New Fuel and Emissions Tables
5. NETSIM Microcomputer version

SICA Signalized intersection capacity for Chapter 9 of the 1985 HCM is available.

Highway Capacity Software (HCS) is not yet available.

Anyone wishing to obtain any of the above should contact:
McTrans Center
University of Florida
346 Weil Hall
Gainesville, Fla. 32611
or call 1-904-392-0378

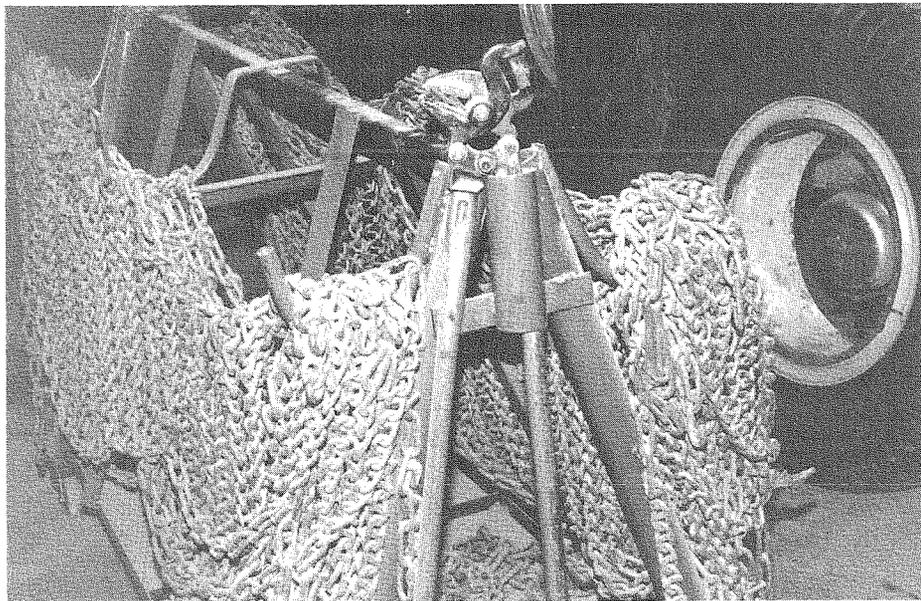
tips from — the field —

Chain rack

The city of Spencer, Iowa, has developed an efficient way to store truck chains. A storage rack keeps the chains clean, safe, and ready for use.

Only repaired chains are stored on the rack, so they can be removed directly from the cart and applied to the tires without worry of them being faulty.

The A-frame is made up of 2-inch pipe with 1-inch square tubing for the longitudinal connecting rod. The intermediate chain support pieces are also made of the 1-inch square tubing.



Do you have tips from the field to share?

Willard Wray is assembling tips for the American Public Works Association and the Technology Transfer Program. Wray has contacted many cities and has received many excel-

lent ideas. However, he notes that people in many shops do not think they have any innovative equipment or operation ideas, but when questioned they turn up excellent ones.

If you think you would like to submit a tip, call Willard Wray at 1-515-223-6230 or write him at: Director of Public Works
City of Clive
Clive, Iowa 50053

APWA completes microcomputer survey

The American Public Works Association's (APWA) Research Foundation has completed a survey on microcomputer use in public works agencies. The survey was designed to gather information on microcomputers in public works agencies in the U.S. and Canada, and to assess the microcomputer needs of public works professionals. Survey questions were based in part on questions from previous surveys by APWA chapters.

Some highlights of the analysis are:

- Even though midsize population agencies reported the greatest number of microcomputers in use, the software budgets were highest for the larger population and staff categories. On the whole, the larger the staff or population size, the larger the software budget.

- Administrative budgeting is the most commonly used area and one of the areas that users rated the most useful. Within the project management area, however, 39 percent of the respondents indicated that their programs needed improvement. This dissatisfaction may be the result of a perception that there exists a relatively small number of off-the-shelf programs available for functions specific to public works.

The "typical" microcomputer user:

- Works in a department of one to 25 people,
- Is an experienced user, and
- Wants to initiate some sort of software exchange program.

The department he or she works in:

- Serves a population of 100,000 to 250,000 people;
- Has between two and five micro-

- computers, probably purchased within the last two years, with a hard disk capacity of 30MB or greater; and
- Spent about \$10,000 this year on software, and intends to spend slightly more next year.

APWA has completed a separate investigation of the programs available to public works professionals. The results of this investigation, including a catalog describing programs for 15 application areas, are available from the APWA Publications Department for \$60.00. Within a year, APWA also will have a similar catalog available on public domain software for public works professionals.

For a copy of the catalog, write APWA Research Foundation, 1313 East 60th Street, Chicago, Ill., 60637.

Bridge Engineering Center

At the June 1986 meeting of the Board of Regents, a proposal for the establishment of a Bridge Engineering Center (BEC) in the ISU Department of Civil Engineering was approved.

The purpose of BEC is to identify the ongoing activities in bridge research, expand them into teaching bridge engineering to graduate students, and develop and promote seminars and short courses for practicing bridge engineers. Establishment of the BEC at ISU will further the effort to expand related activities and, specifically, to promote additional bridge research.

Over the last 15 years, the structural engineering section has had continuous activity in teaching and contract research in the area of bridges.

The BEC is under the direction of an advisory committee comprised of R. R. Dague; F. W. Klaiber—manager of BEC; L. F. Greimann; and W. W. Sanders, both of whom are associate managers of BEC.

The responsibility to know the law

Many of our readers attended one of the Chemical Risks Right to Know satellite video workshops transmitted across Iowa on September 11. Many seemingly harmless materials that are common in the workplace fall into the hazardous category. Those in charge have a responsibility to inform workers of the hazards under penalty for noncompliance. If you don't know what is hazardous you need to find out.

A speaker at the APWA Annual meeting in Okoboji drove this point home when she related an incident on the West Coast. An engineer decided to clean out a storage area and directed some old containers of paint to be sent to the land fill. He subsequently was found guilty by the courts and lost his job because of the conviction.

Attention: Users of SIGOP-III

The Technology Transfer Center has just received an update to the users manual. These are revisions replacing certain pages in the manual. It also explains that the latest diskette should be dated July 1986. Earlier microcomputer programs have some minor errors.

If you are a SIGOP-III user, please write us for an update to this user's manual (dated July 22, 1986) if you have not already received one. Also, if your diskette is not dated as noted above you can receive an updated program for \$6.10 including postage from:

McTrans Center
346 Weil Hall
University of Florida
Gainesville, Fla. 32611

Steam engines and steel rails used to build early Iowa roads

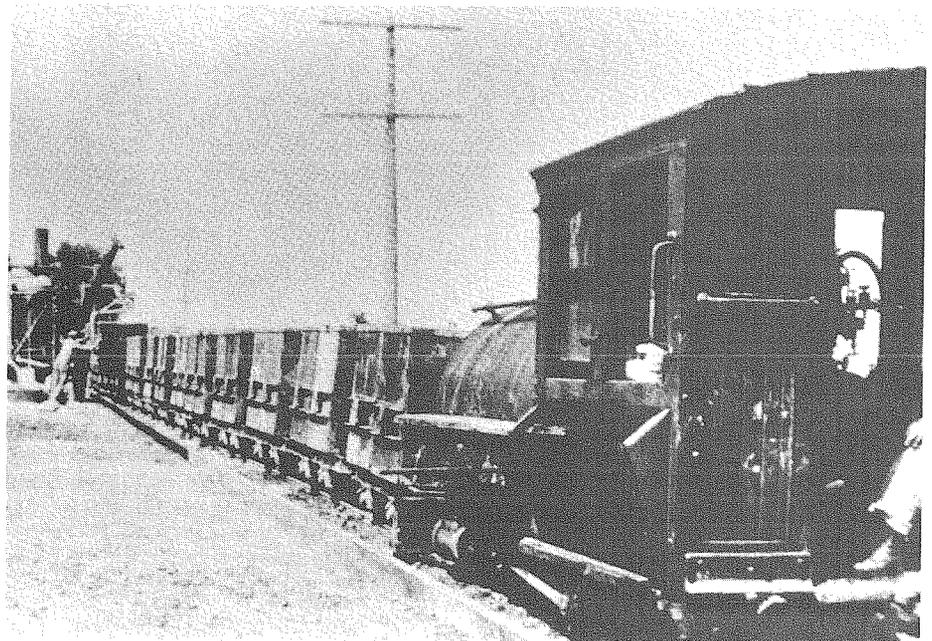
A complete railroad system of tracks and switches, 6-ton steam locomotives, and many small railroad cars were used to build some of Iowa's earliest concrete roads. Batch boxes were loaded with aggregates and four sacks of cement at a central proportioning plant. These boxes were transported, on railroad track laid on the graded roadway shoulder, to the mixer. Usually the

Supreme Court ruling on sidewalks

The Iowa Supreme Court recently upheld a lower court's judgment on a sidewalk case. In the case, a citizen had fallen down on a sidewalk because of the alleged unsafe condition of the walk. The lower court had ruled in favor of a plaintiff noting that "the city has some affirmative duty to make inspections of sidewalk condition with some degree of regularity."

The Iowa Supreme Court agreed with the lower court's decision regarding municipalities' responsibility to check their sidewalk conditions.

mixer was a Koehring 21-E four-bag mixer. A crane would swing the box over the mixer skip and open the bottom. After the pavement was placed, the rail tracks were removed. This technique ensured a good subgrade and fewer workmen were needed. Using this method an average of 500 feet of two lane roadway could be paved each day.



The construction of one of Iowa's early concrete roads.

conference 1 2 3calendar

Iowa Good Roads Association
Annual Meeting
Des Moines
November 6-7

Iowa State Association of Counties,
Fall School of Instruction
Des Moines
November 12-14

Safety Features for Local Roads and Streets

Storm Lake, November 5
Atlantic, November 19
This workshop will provide those involved in local transportation with relevant information on highway safety features. It has been developed by the National Highway Institute for use at the local level. Understandable instruction and teaching aids will help personnel recognize, construct, and maintain safer roads. This workshop is sponsored by the Local Transportation Information Center.

Troubleshooting Concrete Field Problems

Offered by the Portland Cement Association in Skokie, Illinois
November 17-21

Microcomputer Spreadsheet
Applications for County Engineers
Scheman Continuing Education
Building, Ames
November 21

Advanced Concrete Technology
Offered by the Portland Cement Association in Skokie, Illinois
December 1-5

40th Annual County
Engineer's Conference
Scheman Continuing Education
Building, Ames
December 2-4

Asphalt Paving Association of
Iowa Annual Meeting
Des Moines
December 4-5

Iowa Ready Mixed Concrete
Association Promotion Workshop
Scheman Continuing Education
Building, Ames
December 10

ASCE Structural Design Conference
Scheman Continuing Education
Building, Ames
December 18

Iowa Concrete Paving Association
Annual Meeting
Des Moines
January 13

ASCE Water Resources
Design Conference
Scheman Continuing Education
Building, Ames
January 13-15

38th Annual Better
Concrete Conference
Scheman Continuing Education
Building, Ames
January 15

Transportation Research Board
Annual Meeting
Washington D.C.
January 12-16

19th Annual Iowa DOT
Transportation Conference
Scheman Continuing Education
Building, Ames
January 29-30

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