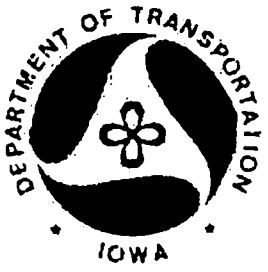
Charles T. Jahren, Lance A. Elliott, Arcot Naresh

Field Data Collection and Reporting Study

Sponsored by the
Iowa Department of Transportation
Project Development Division and the
Iowa Highway Research Board

May 1997

Iowa DOT Project HR-377
ISU-ERI-Ames 96117



Iowa Department
of Transportation

report

FINAL

Deparment of
Civil and Construction Engineering
Iowa State University

Charles T. Jahren, Lance A. Elliott, Arcot Naresh

Field Data Collection and Reporting Study: Section I Overview and Summary

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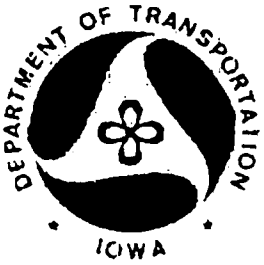

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ABSTRACT

A review of the Iowa Department of Transportation's field data collection and reporting system has been performed. Included were several systems used by the Office of Construction and Local Jurisdictions.

The entire field data collection and reporting systems for ACC paving, PCC paving, and PCC structures were streamlined and computerized. The field procedures for materials acceptance were also reviewed. Best practices were identified and a method was developed to prioritize materials so transportation agencies could focus their efforts on high priority materials. Iowa State University researchers facilitated a discussion about Equal Employment Opportunity (EEO) and Affirmative Action (AA) procedures between the Office of Construction field staff and the Office of Contracts. A set of alternative procedures was developed. Later the Office of Contracts considered these alternatives as they developed new procedures that are currently being implemented. The job close-out package was reviewed and two unnecessary procedures were eliminated. Numerous other procedures were reviewed and flowcharted.

Several changes have been recommended that will increase efficiency and allow staff time to be devoted to higher priority activities. It is estimated the improvements in ACC paving, PCC paving and structural concrete will be similar to three full time equivalent (FTE) positions to field construction, field materials and Office of Materials. Elimination of EEO interviews will be equivalent to one FTE position. It is estimated that other miscellaneous changes will be equivalent to at least one other FTE person. This is a total of five FTEs. These are conservative estimates based on savings that are easily quantified. It is likely that total positive effect is greater when items that are difficult to quantify are considered.

INTRODUCTION

Field data collection and reporting (FDC&R) is a critical task performed by the Iowa Department of Transportation (DOT) Construction, Materials and local jurisdictions. The data includes measurements for contractor payments, test results, progress reports, and other information necessary for construction project administration. The system that existed before this study was a manual system that developed incrementally as needs arose. The system required a multitude of forms and generated a multitude of reports. Many of the forms required employees to manually copy information from one form to another that merely presents the information in a different format. It was unclear whether or not the report forms suited the needs of the users.

Iowa DOT construction personnel were aware of the need to review the FDC&R process. Task groups had examined various types of construction projects and listed required forms and their sources and destinations. Other task groups were involved in efforts to increase computer usage among the construction field staff. When this project was started in January of 1995, the Electronic FieldBook was being pilot tested. This system tracks pay quantities (item progress) and prepares pay vouchers for contractors. During the time of this study, Iowa DOT was also participating in the development of the computer program SiteManager (formerly CMS -- Construction Management System) by AASHTO (American Association of State Highway and Transportation Officials). SiteManager will be a comprehensive construction administration program that will track contractor payments, material test results, schedules, change orders and civil rights issues. The SiteManager is being developed in a manner so that each state may customize it to fit its own procedures. Iowa DOT will invest considerable effort when it customizes SiteManager for its own use. Before this effort is expended, it is necessary to review procedures to ensure efficiency. One of the objectives of this project was to provide such a review.

The Office of Construction did not have enough staff time to conduct this research. Tasks included facilitating meetings, examining information flow for certain processes in detail, checking reporting requirements, and developing recommendations for a revised process. Therefore, this research project was funded by the Iowa Highway Research Board. The research was conducted by Iowa State University (ISU) graduate and undergraduate students under the supervision of Dr. Charles T. Jahren, Assistant Professor, Department of Civil and Construction Engineering.

The research team was guided by a review committee that included the Iowa DOT Field Systems Engineer, Senior Engineering Technicians from each of the six transportation center regions, and representatives from the Iowa DOT Office of Local Systems, the county engineers, and the Federal Highway Administration. The researchers and review committee met on a monthly basis. During the meetings, committee members provided information to the research team and reviewed research products. Review committee members also assisted with technology transfer and implementation, because they were familiar with details of the development of the procedures.

DETAILED OBJECTIVES AND PRIORITIES

During the initial meetings with the committee, detailed objectives and priorities were selected. This was done by identifying portions of the FDC&R system that receive heavy use and portions that appear to be cumbersome or unnecessarily time consuming. The objectives selected are the following:

1. Eliminate needless paperwork so employees can concentrate on higher priority tasks.
2. Provide time-sensitive information on a timely basis.
3. Standardize procedures between offices.
4. Centralize storage of information.
5. Develop procedures that are compatible with future computerized improvements.

6. Develop procedures that can be reviewed regularly and updated easily.
7. The final report should be written so that it can be used as an orientation aid.

Eliminate Needless Paperwork

There is a general concern that inspectors spend too much time on paperwork and not enough time observing construction. It is desirable to eliminate paperwork to the extent possible. Field data collected in field books are usually copied to one or more forms to be sent to other offices. Such copying should be eliminated if possible. Each item of information collected should be traced to its ultimate destination to find out if it is still necessary to collect. Unnecessary items should be eliminated.

Provide Time-sensitive Information on a Timely Basis

Some of the field data reports are sent to other offices on a daily basis, some on a weekly basis. Delays sometimes occur when the report cannot be completed because of missing information; other times delays occur while the report waits to be reviewed. Researchers will investigate methods to separate time-sensitive information and eliminate unnecessary reviews.

Standardize Procedures Between Offices

The procedures followed by transportation centers and residencies are not uniform throughout the state. If procedures were standardized, changes would be easier to implement on a state-wide basis because one change could be implemented in the entire state rather than applying different versions of the change for each office. It would be easier for people to temporarily transfer between offices if procedures were standardized. Such transfers have become more common recently as attempts are made to balance work loads between offices.

Develop Procedures Compatible with Future Computerized Improvements

When existing field data collection and reporting procedures are reviewed, changes were considered to make procedures compatible with future computer tools. Examples of such tools include AASHTO SiteManager and pen-based notebook computers.

Develop Procedures that can be Reviewed Regularly and Updated Easily

Researchers must understood that the system will continue to evolve. The recommended procedure have the flexibility to change with future demands.

Write the Final Report so it can be Used as an Orientation Aid

Current Iowa DOT training materials primarily explain how certain procedures are to be performed. The final report explains why procedures are performed and who is using the information. If employees understand why the information is needed and who uses it, they will be motivated to perform better.

STUDY OVERVIEW

The research project commenced with a series of discussions with the review committee to identify portions of the field data collection and reporting system that had highest priorities for improvement. Highest priority was assigned to items that were heavily used, or identified by many people as inefficient. The ACC paving, PCC paving, and PCC structures reporting systems were identified as high priority areas because they are in constant use in most construction projects. Also, these procedures require a considerable amount of information to be copied from form to form.

Equal Employment Opportunity (EEO) and Affirmative Action (AA) procedures were identified as high priority areas because the previous system required considerable effort that did not directly advance the goals of the program. Job close-out procedures were also identified because every job must be closed out and because some job close-outs were being delayed by procedural matters. In particular, materials acceptance documentation was identified as being especially problematic.

were being delayed by procedural matters. In particular, materials acceptance documentation was identified as being especially problematic.

Researchers focused on these high priority areas in the early part of the study. As the study progressed, the review committee identified several other procedures that required study. These procedures were discussed during review committee meetings. ISU researchers developed flowcharts for these processes and assisted in making recommendations for improvement. Such activities resulted in several incremental improvements, better documentation, and a more uniform understanding of the procedures by review committee members that are responsible for implementation.

EEO AND AA COMPLIANCE MONITORING

The objective of the Equal Employment Opportunity (EEO) policy is to ensure that employment is provided without regard to race, religion, sex, color, national origin, age or disability. It is intended to prevent and eliminate discriminatory practices as well as promote fairness and equality of opportunity within organizations. Affirmative Action (AA) includes specific steps taken to assure minorities and women will have equitable opportunity for employment. AA is intended to go beyond the mere avoidance of discrimination (non-discrimination); it is intended to eliminate employment imbalances affecting minorities and women.

The standards for EEO and AA in federal aid projects are outlined in a series of federal laws, executive orders, rules, regulations and orders of the Secretary of Labor (28 CFR 35, 29 SFR 1630, 41 CFR 60, 23 U.S.C. 140). Iowa DOT contracts reference specifications set forth under 41 CFR 60-4.3 and the provisions of the Americans with Disabilities Act of 1990 (42 U.S.C. 12101 *et. Seq.*) set forth under 28 CFR 1630. The standards for non-federal aid projects are set forth in the Iowa Civil Rights Act of 1965, as amended, current Iowa Administrative Rules, and Iowa Executive Order 15.

The Iowa DOT has developed a compliance monitoring program to ensure that:

- The contractors attempted in good faith to recruit minority and women employees.
- The contractors conduct systematic and direct recruitment through public and private employee referral sources likely to yield qualified minority group applicants.
- The contractors publish advertisements for employment in newspapers or other publications having a large circulation among the minority community.
- If contractors rely on unions as a source of employees, the contractors have used their best efforts to obtain the cooperation of those unions to increase the opportunities for minorities and women.
- Communication tools such as notices and posters explaining the contractors' equal opportunity policy are posted in areas readily accessible to employees, prospective employees, and applicants for employment.

During initial meetings, the review committee identified compliance monitoring activities for EEO and AA as an area where field data collection and reporting efficiency could be increased. At the beginning of this study, there were two major compliance monitoring activities: EEO interviews documented on form 650170 - Project Engineer EEO Project Site Inspection Report (Figure 1) and EEO compliance reviews.

Inspectors from the Iowa DOT field construction and local jurisdictions conducted EEO interviews for every prime contractor and subcontractor on every project that holds a contract in excess of $10,000. Superintendents were interviewed using form 650170 which served as a checklist for questions and provided space to record interview results. The completed form was sent to the Office of Contracts and a copy was retained in the project file. The completed forms were reviewed by the EEO Compliance Officer who followed up on any indications of noncompliance. Approximately 2000 EEO interviews were conducted each year.

EEO Compliance reviews were conducted by the EEO Compliance Officer at the contractor's home office. Before the compliance review, the Compliance Officer would

request the Project Engineer to conduct a special EEO interview for the company that was being reviewed and return the results on form 650170. The Compliance Officer would use the interview results to plan his compliance review. The Compliance Officer would travel to the contractor's home office and conduct the review. The review would last one to two days. If the review indicated that the contractor was not complying with EEO requirements, the Compliance Officer would issue a *Show Cause Notice*. The contractor was required to remedy the situation. Approximately 50 compliance reviews were conducted each year. Representatives from the Office of Contracts met with the review committee during three monthly meetings to define areas where improvement was needed and to develop alternative solutions. Two special meetings were also held that were attended by Office of Contracts Personnel and ISU researchers. The findings of this investigation follow.

Most of the EEO interviews (form 650170) indicated compliance (above 99%) while instances of noncompliance (many are minor) were detected during 50 to 80% of the compliance reviews. The requirement to conduct EEO interviews for every project resulted in many repetitions of the similar EEO interviews, especially for subcontractors that move frequently from one project to another. Some subcontractors that moved on a daily basis were interviewed on a daily basis. With so much repetition, the participants did not take the interview requirements seriously. recommended procedure should have the flexibility to change with future demands.

Alternatives

Using input from the meetings, ISU researcher developed three alternatives for consideration by the Office of Contracts. Since the EEO compliance review was found to have greater effectiveness, each alternative decreases the number of EEO interviews. This reduces effort for the Project Engineer's staff and allows the Office of Contracts to focus on the more productive EEO compliance reviews.

Form 650170
7-90

Iowa Department of Transportation

RESIDENT CONSTRUCTION ENGINEERS/COUNTY ENGINEERS
E.E.O. PROJECT SITE INSPECTION REPORT

CONTRACTOR: _____ PROJECT NO: _____

ADDRESS _____ COUNTY: _____

☐ Prime ☐ Subcontractor ☐ First Reporting ☐ Second Reporting DATE: _____

Dollar Amount of Contract	Beginning Construction Date	Percent Complete	Type of Construction

INTERVIEW WITH CONTRACTOR'S SUPERVISOR Name _____ (Contractor's Representative)

	YES	NO
1. Are all required E.E.O. posters, policy statements and manpower training programs properly displayed?	☐	☐
2. Has contractor submitted letter of compliance at start of work?	☐	☐
3. Does company E.E.O. Officer make visits to project? How often? _____	☐	☐
4. Was an EEO meeting of the contractor's supervisory personnel held before start of work? Date: _____	☐	☐
5. Was a follow-up meeting held if project lasted longer than 6 mo.? Date: _____	☐	☐
6. Are employee facilities provided on a non-segregated basis?	☐	☐
7. Does the contractor receive job applications at project site?	☐	☐
8. Is an active file or record of job applicants kept at project site? How are applicants contacted? _____	☐	☐
9. Does contractor rely on union referrals exclusively? If not, for which crafts? *(please list)*	☐	☐
10. Does contractor have an approved training program? Please check: ☐ AGC ☐ ARBIA ☐ ILPA ☐ Direct *(Approved by Iowa DOT)*	☐	☐

11. How are new personnel informed of E.E.O. policy and available training?

12. How is the prime contractor monitoring all sub-contractors to assure compliance with E.E.O. obligations?

INTERVIEW OF EMPLOYEES

13. Have employees met or been interviewed by contractor's E.E.O. officer or E.E.O. representative? If yes, when _____ (Mo Day Yr.)	☐	☐

14. How are employees made aware of company's E.E.O. policy?

15. List the names of in Reimbursible Trainees and work categories *(when applicable)*.

Figure 1. Form 650170 - Project Engineer EEO Project Site Inspection Report

Alternative One

Under alternative one, EEO interviews (form 650170) would be retained, however, the number of interviews would be reduced. A sampling process would be developed to ensure that contractors would be interviewed between one and five times per year, depending on their level of activity. In addition, interviews would be conducted before EEO compliance reviews. Interview dates and results would be stored in a centralized data base that would be used as an aid for planning future interviews. Project Engineers would be notified of needs for interviews by letters sent by the EEO Compliance Officer. These revisions would reduce the number of EEO interviews from 2000 per year to 500 per year.

EEO compliance reviews would continue to be conducted as they were previously. Inspectors would continue to check to make sure posters and notices are posted and would monitor the project for indications of discrimination and segregated facilities. This alternative would have the following advantages:

- There would be fewer repetitions of interviews, so participants would take them more seriously.
- Since there are fewer interviews, inspectors could spend more time and go into greater depth.
- Less effort would be expended conducting interviews and processing 650170 forms.

This alternative would have the following disadvantages:

- A few instances of EEO noncompliance might go undetected.
- Awareness of EEO and AA issues may be reduced in the field.
- The change may send a message to the field that EEO and AA compliance are not as important as it used to be.

Alternative Two

Under Alternative Two, the number of EEO compliance reviews would be increased. EEO interviews would be conducted only when an EEO compliance review is conducted. All interviews would be conducted by EEO Compliance Officers. It is expected that an EEO specialist could interview more skillfully and develop a better understanding for contractor field operations that could be helpful during compliance reviews. Project Inspectors would continue to check to ensure that posters and notices are properly posted and that indications of discrimination and segregated facilities do not exist.

This alternative would require more staff for the Office of Contracts. Currently there is one EEO Compliance Officer and it would be difficult to significantly increase the number of compliance reviews above the current 50 reviews per year. Requiring the EEO Compliance Officer to conduct EEO interviews would further add to the work load. Since many project sites are located away from Ames, considerable travel time would be required.

The advantages and disadvantages of alternative two would be similar to the ones listed for alternative one. Alternative two would have the following additional advantages:

- The number of compliance reviews performed each year would be increased.
- Since the person performing the EEO compliance reviews would also perform the EEO interviews, the process would be more seamless.
- The EEO Compliance Officers are likely to have greater skill in conducting the EEO interviews than the inspectors.

Alternative two would have the following disadvantages:

- The level of staffing would have to be increased in the Office of Contracts
- The EEO Compliance Officers would spend more time traveling to conduct interviews

Alternative Three

Alternative three is similar to alternative two, except that Inspectors would conduct the EEO interviews. This would reduce the requirement for EEO Compliance Officers to travel. However, the compliance monitoring process would not be as seamless and the interviewers may be less skillful.

Implementation

After the three alternatives were presented, the Office of Contract developed a final alternative. It was decided to concentrate efforts on the EEO reviews because they are the most effective tool for EEO compliance monitoring. The current EEO interview has been eliminated. However, when necessary as part of an EEO compliance review, the EEO Compliance Officers will ask the Project Engineer's staff to interview field personnel. Instructions and a list of questions will be developed that specifically meet the needs of the review. As with the other alternative, Inspectors will continue to see that notices and posters are properly posted, that facilities are not segregated, and that there are no apparent signs of discrimination in the field.

The revised policy was presented to the FHWA and approved. It was implemented as Supplemental Specification SS-5171 and SS-5171M in February 1997. The revised policy will result in the elimination of approximately 2000 EEO interviews. Since it is estimated that at least one hour of staff time is required to conduct the interview and document the results (meet the contractor, fill out the form, and make copies, file and mail the form), this revision will save 2000 hours of staff time per year. This is equivalent to one FTE. The time saved can be used for field inspection.

Contractors EEO/AA Policy

Each contractor that holds a contract or subcontract in excess of $10,000 is required to have an EEO/AA policy that is approved by the Iowa DOT. It was previously required that a copy of this policy be submitted at the pre-construction conference for each

contract. Participants at the review committee meeting, both from the Office of Contracts and the Office of Construction recommended that this requirement be eliminated. Contractors would typically photocopy a year's supply of policies and bring one to each pre-construction meeting. Project Engineers would incorporate them into the project file. They were seldom referenced after that. It was recommended instead that contractors submit their EEO/AA policy to the Office of Contracts each year for approval. The Office of Contracts would not issue a contract and the Transportation Center would not approve a subcontract unless an approved EEO/AA policy was on file with the Office of Contracts.

On-the-Job Training

During some of the review committee meetings, participants discussed concerns about the training program. In this program, the Iowa DOT pays contractors on selected contracts $0.80 per hour to train workers in skills necessary for transportation construction. Priority is given to training female and minority workers in underrepresented classifications. The intent of the program is that the contractor will retain workers in the training program until they are fully trained. It was usually necessary for a contractor to retain a worker for several Iowa DOT contracts before the worker was fully trained. Since training hours were tracked on a contract by contract basis, it was not possible to ensure that workers were being completely trained before being moved out of the program. At the end of a contract, it would be possible for a contractor to lay off trainees and hire new ones at the beginning of the next contract. Thus, the Iowa DOT was meeting its goal of starting women and minorities in the program but was not meeting its goal of retaining them in the program.

In response to this concern, the Office of Contracts developed a pilot On-the-Job Training Program for two years commencing, February 18, 1997, (Supplemental Specification SS 5174M and SS 5174). Contractors enter the program by submitting an application describing: 1) their long term training needs for labor classifications that are underrepresented for women and minorities, and 2) their plan for providing the training. If the application is approved, the contractor is reimbursed for training hours on all Iowa

DOT construction projects at a sliding rate that increases with the amount of training provided ($2.00 per hour for the first half of the training period, $3.00 per hour for the third quarter of the training period, and $5.00 per hour for the fourth quarter of the training period), thus providing incentive for contractors to fully train workers. The Iowa DOT will monitor the effectiveness of the contractors by interviewing trainees, sending self-mailer letters to trainees, conducting contract compliance reviews, verifying payrolls, and other methods. Contractors are reimbursed for training by an change work order. Contractors who do not participate in the pilot program will continue to provide training under the $0.80 per hour program.

ACC PAVING, PCC PAVING, AND STRUCTURAL CONCRETE

A large portion of Iowa DOT construction activities involves paving (both PCC and ACC) and structural concrete. Considerable effort is required to properly document these activities. Discussions with the review committee indicated that the procedures for documenting ACC paving, PCC paving, and structural concrete had a high priority for improvement efforts. These improvement efforts commenced at the beginning of this project and represent the majority of the research activities in this contract. A full report of the improvement efforts is provided in Section II. A brief summary of the improvement activities follows.

Researchers started by examining the current system and interviewing Iowa DOT employees and contractors to locate areas of inefficiency and to obtain ideas for improvements. The existing system has evolved over several years. The original system was devised when the construction field staff was greater in number and before copy machines, faxes, and computers were available. Since then, additional modifications have been made as additional needs have arisen. The original system required personnel to copy information from plant books, field books, and other forms onto summary reports: Form 830224 -- Combined Daily Inspection Report of Portland Cement Concrete Paving (Figure 2); Form 830211 -- Weekly Concrete Report; and Form 820007 Daily Plant

Report of Bituminous Treated Base, Asphalt Treated Base, and Asphalt Concrete. These summary reports were checked several times and ultimately archived in the Ames Central complex. The reports included some time-critical information that the Transportation Center Materials Engineers (TCMEs) used to assure the quality of ACC and PCC materials. However, this information was not delivered in a timely manner because the reports were checked by several people first and then delivered by mail.

After researchers developed an understanding of the previous system, they conducted interviews with the users of the information on the reports. Users were asked how they used the information and when they needed it. As mentioned previously, it was found that the TCMEs needed certain plant information quickly for quality assurance purposes. The balance of the information was used during the project to monitor progress and at the end of the project for the audit.

Researchers developed a new system that reduced the requirement for copying and quickly provided time critical information to the TCMEs. New plant book pages were developed that included time critical information. Form M240, Concrete Plant Page is an example (Figure 3). When completed, this page is faxed directly to the TCME. The information needed for the audit is retained in the plant book. At the end of the project the plant book is included in the audit package. Information needed regarding project progress may be satisfied by making notations on the Weekly Report of Working Days.

After the new system was devised, Dan Steenhard, a field inspector at the New Hampton Residency, developed a set of Lotus 123 spreadsheets that complement the new system. These spreadsheets perform most of the routine calculations. They also electronically copy entries from one report to another in the few cases of required duplicate data entry.

Form 830224(E)
4-94

COMBINED DAILY INSPECTION REPORT OF PORTLAND CEMENT CONCRETE PAVEMENT

Contract No. _____ Contr. _____ Res/Co. Engr. _____ Project _____ County _____

Report No. _____ Date _____ Date of Last Report _____ Plant Owner and Location _____ Sq. Yards (Cont. Qty.) _____

Weather _____ Days Temp. Max. _____ Min. _____ Min. Temp. Foll. Night _____ Plant Insp. _____ Cert. No. _____

Item/ Lane	STATION From	STATION To	Length Feet	Sq. Yards	CU. YDS. Est.	CU. YDS. Batched	CU. YDS. Used	% of Est. Used	Time Start / End	Mix No.	DRY BATCH WEIGHTS F.A.	DRY BATCH WEIGHTS C.A.	MOISTURE CONTENT F.A.	MOISTURE CONTENT C.A.	ACTUAL QUANTITIES USED PER CU. YD. (IN POUNDS) Cement	Fly Ash	Fine Aggr.	Coarse Aggr.	Water in Mat'ls.	Water Added at Plant	Water Added at Grade	Total Water	Slump	Air	Hand Fin.
									/																
									/																
									/																
									/																
									/																
									/																
TOTAL ▶																									
PREVIOUS TOTAL ▶																									
TOTAL TO DATE ▶																									

Total Cement Batched _____ Total Fly Ash Batched _____ Total Water _____

Maximum Allowable Water _____ Brand of Air Admixture _____ Ave. Water/Cement _____

Calcium Chloride ☐ Yes ☐ No Max. Water/Cement _____

Water Reducer ☐ Yes ☐ No Brand _____ Normal Batch Size _____

Source:

Fly Ash _____ Sp. Gr. _____

Fine Aggr. _____ T-203 No. _____ Sp. Gr. _____ Plant Test _____

Coarse Aggr. _____ T-203 No. _____ Sp. Gr. _____ Plant Test _____

Certified Aggregate Verification Coarse Aggr. Durability _____

Fine aggregate _____ tons Coarse Aggregate _____ tons

Time Lost And Cause _____

Type of Subgrade _____

CEMENT Brand	Type	Ticket No.	Amount Tons
FLY ASH			

Method of Curing

Texture Method

BEAMS MADE Time	Beam No.	Slump	Air

Method of Covering Subgrade
☐ Plastic ☐ Moistened
☐ Slip Form ☐ Fixed Form
Method of Mixing
☐ Central Mix ☐ Transit Mix
Cold Weather Protection ☐ Yes ☐ No

BEAMS TESTED Beam No.	Mix No.	Age Days	Depth inches	Width inches	Slump	Air	Ind. Load	Act. Load	Computation Factor	Mod. of Rupture	Location of Break

Sample I.D.	Grad. No.	AGGR SIEVE ANALYSIS PERCENT PASSING 1½ IN	1 IN	¾ IN	½ IN	⅜ IN	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	COMP.

Additional Slump, Air Tests, Remarks _____

Figure 2. Form 830224 - Combined Daily Inspection Report of Portland Cement Concrete Paving.

8/96

PCC Plant Page

Form M240

Page: _____

Project No.: NHSN-63-9(19)--2R-45 | County: Howard | Report No.: 6

Plant Name: Croell R/M - Elma | Weather: | Date This Report: 07/13/96

Contractor / Sub: Wicks Construction - Sub | Min. Temp. (°C): | Date Of Last Report: 07/06/96

Contract ID.: 45-0639-019 | Max. Temp. (°C): | Design No.: 748

Check One (x)		Check One (x)		
Central Mix		Paving	x	(Send Daily or End of Lot)
Ready Mix	x	Structure	x	(Send Weekly or End of Lot)
Mobile Mix				(Send Weekly or End of Lot)

Year 1998 Date	Mix Number	Time Start	Time Stop	Batched (m3)	% of Est. Used	Fine Aggregate Moist. (%)	Fine Aggregate T-203 Sp. G.	Fine Aggregate Dry Wt. (kg)	Coarse Aggregate Moist. (%)	Coarse Aggregate T-203 Sp. G.	Coarse Aggregate Dry Wt. (kg)	Actual Quantities Used Per m3 (in kilograms) Cement	Fly Ash	Fine	Coarse	Water In Agg.	Water Plant	Water Grade	Avg. W/C Ratio	Max. W/C Ratio
07/09	D-57			5.73	101.1	3.6	2.65	832.0	0.4	2.54	798.0	421.0		863.0	801.0	34.0	149.0	1.0	0.437	0.450
07/10	M-4			1.91	100.0	3.6	2.65	827.0	0.4	2.54	790.0	490.0		858.0	793.0	34.0	147.0	1.0	0.371	
07/12	C-4			50.84	100.7	3.6	2.65	877.0	0.7	2.54	843.0	371.0		910.0	849.0	39.0	131.0		0.458	0.488

Coarse Aggregate

	Sieve Size	Sieve Accuracy= 100.0% Wt. Retd.	% Retd.	% Retd.	% Psg.	Sieve Accuracy= Wt. Retd.	% Retd.	% Retd.	% Psg.	Sieve Accuracy= Wt. Retd.	% Retd.	% Retd.	% Psg.	Specs.	Avg.
	Orig. Dry Weight (OD Wt.):				6808.7	Orig. Dry Weight (OD Wt.):				Orig. Dry Weight (OD Wt.):					
	Dry Wt. Washed (D Wt. W):					Dry Wt. Washed (D Wt. W):				Dry Wt. Washed (D Wt. W):					
C	37.5mm				100.0									100	
O	26.5mm	26.1	0.4		99.6									95-100	
A	19mm	1658.2	24.3		75.3										
R	13.2mm	2463.0	36.2		39.1									25-60	
S	9.5mm	1637.4	24.0		15.1										
E	4.75mm	999.8	14.7		0.4									0-10	
S	2.36mm	22.4	0.3		0.1									0-5	
A	Pan	5.0	0.1												
M	Total	6809.9	100.0												
P	75um				0.6									0-1.5	
L	Wash Loss	18.9	OD Wt.:	3294.4			OD Wt.:				OD Wt.:				
E	Pan	2.4	D Wt. W.:	3275.5			D Wt. W.:				D Wt. W.:				
W	Total	21.3													

Check One (x):	Today	Week x	Total
Concrete Batched(m3)		58.48	732.63
Cement Batched(Mg)		22.21	343.56

	Brand / Source	Rate	Lot No.
Air Entrain:	DV 1000 - WR Grace		CF03 A183-8
Wat. Red:			
Retarder:			
Cal. Chlor:			
Superplas:			

Concrete Treatment (x)	kg / m3
Ice	
Heated Water	
Heated Materials	

Fine Aggregate

	Sieve Size	Sieve Accuracy= 100.0% Wt. Reld.	% Retained	Final	% Passing	Sieve Accuracy= Wt. Reld.	% Retained	Final	% Passing	Sieve Accuracy= Wt. Reld.	% Retained	Final	% Passing	Specs.	Avg.
	Orig. Dry Weight:				637.8	Orig. Dry Weight:				Orig. Dry Weight:					
	Dry Wt. Washed:				633.9	Dry Wt. Washed:				Dry Wt. Washed:					
	Washing Loss:				3.9	Washing Loss:				Washing Loss:					
F	9.5mm				100.0									100	
I	4.75mm	29.1	4.6		95.4									90-100	
N	2.36mm	55.1	8.6		86.8									70-100	
E	1.18mm	85.1	13.3		73.5										
S	600um	144.6	22.7		50.8									10-60	
A	300um	225.2	35.4		15.4										
M	150um	87.8	13.8		1.6										
P	75um	6.0	0.9		0.7									0-1.5	
L	Wash	3.9	0.7												
E	Pan	0.8													
	Total	637.8	100.0												
	Date Reported (DR):	07/09/96				(DR):				(DR):					
	Tested By/Date (TB/D):	Doug Kronneman		NE-386		(TB/D):				(TB/D):					

Mobile Mixer	
Cement Meter	Water Meter

Remarks
C-4 mix was used for bridge approaches.
D-57 mix was used for barrier rails.

C.P.I.: Doug Kronneman — Cert. No. 795

Monitor: Danny Steenhard — NE-386

Figure 3. Form M240 - Concrete Plant Page

Use of the Lotus spreadsheet will be required for QMA asphalt projects and highly encouraged for all other projects. QMA asphalt contractors will be required to purchase computer equipment that can run the programs for the 1997 construction season. A recommendation was developed for the computers in the spring of 1996, so contractors could plan their computer purchases:

- 486-33 MHz processor
- 16 MB of RAM
- 14.4 fax modem
- 500 MB Hard Drive
- CD ROM Drive
- Bubble jet, ink jet or 24 pin dot matrix printer
- Windows 3.1 operating system
- Lotus 5.1 Electronic Spreadsheet

The fax modem was specified so reports could be sent directly from the computer to the TCME. This improves the clarity of the report. The CD ROM drive was specified to ensure compatibility with future versions of the Specifications and I.M.s (Intructional Memorandums) that will be provided on CD ROM.

The systems were pilot tested during the summer of 1996. For the PCC paving and PCC structures, each Transportation Center chose two projects to pilot test. For the ACC paving system, certain contractors volunteered to pilot test the new system as part of their QMA activities. The pilot tests were generally successful. The field staff was pleased with the system because less time was required to complete the reports. The TCMEs liked the system because time critical plant information is provided more quickly. Minor changes were made in the systems in response to comments obtained during the pilot testing. Now the system is ready for full implementation for the 1997 construction season. Researchers provided the Office of Materials with narrative descriptions and flowcharts of the process. These items were included in the 1996/97 winter training program to familiarize the field staff with the new system.

The new system will greatly increase the efficiency of field procedures for paving and structural concrete. The new system for ACC paving has 55% fewer entries than the old system and the system for PCC paving has 42% fewer entries than the old system. The Lotus spreadsheet eliminates manual calculations and further reduces the need for copying. Time critical quality assurance information is provided to the TCME's the day after the report is made.

By using the new system, construction administration agencies will save staff time. This time may be used elsewhere in a way that provides greater value. It is estimated that the Iowa DOT processes approximately 3000 plant reports per year in the primary system. Additional reports are generated by local systems users. Informal conversations with DOT employees indicate that the new system saves approximately two hours per form. If each staff position represents 2000 hour per year, implementation of the new system will be equivalent to adding three FTE positions to the field construction, field materials and Office of Materials with little additional cost. Contractors and local systems users will reap additional savings that are difficult to quantify.

MATERIALS ACCEPTANCE DOCUMENTS

An effective material acceptance policy is an important aspect of construction administration. The material acceptance policy should ensure that the materials incorporated into the construction project are in reasonably close conformity with the specifications. These specifications were devised to ensure safety for transportation users and good performance for the facility. The material acceptance policy should be structured so that timely remedial action may be taken when problems occur. One important field staff function is collecting and tracking materials acceptance documents. These documents include certifications, material test reports, and field book notes on the source and quality of materials. Iowa DOT policy is that materials will not be incorporated into the work until the materials acceptance documents have been collected.

Researchers investigated possible improvements in field procedures for material acceptance. Discussions with the review committee and interviews with the field staff revealed several opportunities for improvement:

- The current procedures are confusing for the construction field staff. This is especially true if they are working with unfamiliar materials because they have difficulty finding and understanding the requirements in the I.M.s (Instructional Memorandums).
- Field document collection and tracking procedures are non-uniform. During a project, many field offices do not know whether or not they have enough materials acceptance documents to cover the materials on the project.
- Job close-out is often delayed because materials acceptance documents are missing. In some cases the missing documents are for items that have little impact on public safety or the long-term economy of the facility.

For routine situations and uncomplicated projects, the current materials acceptance policy works well. Routine situations are those situations where inspectors, contractors and materials suppliers are completely familiar with the materials acceptance policies for the materials that they are handling.

Researchers investigated the Iowa DOT materials acceptance policy and worked closely with the review committee and the Office of Materials to develop recommendations for improvement. This investigation is completely documented in Section III of this report and briefly summarized in the following paragraphs. The investigation was conducted in three major parts:

1. Researchers investigated best practice for collecting and tracking materials acceptance documents.
2. Researchers developed a materials classification system that will allow the Office of Materials to prioritize the materials
3. Researchers recommended a standard distribution method for materials acceptance documents

Collecting and Tracing Materials Acceptance Documents

Researchers investigated best practices for collecting and tracing materials acceptance documents. Two best practices were found:

a) The Des Moines Residency developed a system for filing and tracking materials acceptance documents. The residency constantly checks the amount of material certified against the amount of material in place. If the amount of material in place exceeds the amount certified, the problem is noticed and resolved as quickly as possible. Before this system was started, the quantity of certified materials were not checked until the end of the project. If there was a deficiency, it was difficult to resolve.

b) The East Central Iowa Transportation Center has developed a computer data base program that lists the materials acceptance requirements for each bid item on an entire project. When a list of bid items is submitted, the program returns the materials acceptance requirements for those bid items. This list is provided to the field staff for easy reference.

Materials Classification System

Researchers developed a system to prioritize materials. After the materials are prioritized, the Office of Materials may revise the materials acceptance policy. The highest level of scrutiny will be given to high priority materials. Meanwhile enough inspection effort will be maintained for other materials to assure quality. Expert opinion will be used to prioritize materials. Their contribution to human safety and long term economic efficiency will be considered. Manufacturing uniformity will also be considered. A method was also developed to determine which materials required testing and which materials require only a manufacturer's certification.

Standard Distribution Method

Researchers recommended a standard distribution method for materials acceptance documents.

Implementation

The recommendations from the investigation are currently being implemented. The best practices for materials acceptance document tracking have been incorporated into SiteManager, an AASHTO computer program that Iowa DOT will beta test in 1997. This program is expected to become the standard construction administration program for Iowa DOT construction projects. The materials classification system is currently being reviewed by the Office of Materials. This review is being performed by MARG (Material Acceptance and Rating Group). The group will also consider the recommendation to revise the distribution on materials acceptance documents.

WAGE RATE MONITORING

Federally funded construction contracts require contractors to pay their employees minimum wage rates as stipulated in the Davis Bacon Act (1931). The minimum wage rates are published in a wage decision. This wage decision is included in each construction contract by reference. The wage rates vary by location (usually by county) and by job classification. The job classification refers to the type of work that the employee is performing such as carpenter, laborer, or ironworker. The Iowa DOT monitors wage rates in two ways: by reviewing certified payrolls and by conducting wage rate interviews.

Certified Payroll Review

Contractors and subcontractors submit certified payrolls that list all of the employee on a particular job, the number of hours worked, the job classification, and the amount paid in wages and benefits. The Iowa DOT reviews the certified payrolls to ensures that the right wage is being paid for each particular job classification and location. This review is usually done by a secretary in the Project Engineer's office. The reviewer is required by the Construction Manual to carefully review the first few payrolls submitted

by a prime contractor or subcontractor on the project. After the first few payrolls pass with little change, the rest are reviewed less closely.

Researchers investigated this process through discussions with the review committee and interviews during field visits. The certified payrolls are a large portion of the documents in a typical project file. However, their review is a low priority task that is accomplished by the secretary in between other tasks. Although it can be time-consuming during the height of the construction season, it does not represent a large problem otherwise. Given the necessity to review the payrolls, the researchers could not recommend an improved process.

The Office of Contracts was concerned because the secretarial staff, who usually perform the review, cannot review the job classification information. This is because the secretaries are not working in the field and do not know the type of work that the workers are performing. For example, a certified payroll may indicate that the entire crew is working as laborers on a particular project. In reality, the project may involve concrete forming with a considerable amount of carpentry work being performed. If the wage rates for laborers are correctly applied to the payroll, the reviewer would have no knowledge to take exception to the payroll. In many cases, workers will not complain, either because they do not know their rights or because they do not want to risk displeasing their employer. Occasionally, a worker will file a claim after being laid off. The Contracting Authority is required to assist the Department of Labor in investigating such a claim.

Researchers considered methods to provide a review for job classifications as part of the certified payroll review. The project field staff is in the best position to perform this review; however, there will be limitations. On large projects, the field staff does not know the names of all the workers and will not be able to track the type of work they are doing with only a reasonable amount of effort. On some jobs turnover is very high. On other jobs, workers move from one job to another, possibly staying for only one or two days. Given these challenges, it is unreasonable to expect the field staff to review the job

classification of each employee. However, it would be possible for the field staff to know the general breakdown in job classification. For example, if a contractor was building formwork and the certified payroll showed no carpenters, the field staff could be expected to take exception to that situation. Therefore, it is recommended that the field staff and wage rate reviewers communicate regarding job classifications. This communication could be accomplished with phone calls or radio messages. The objective would be to ensure that the portion of various job classifications is reasonable. Communication should be more frequent in situations where miss-classification is more likely, such as the first few payrolls of a new project or when working with a contractor who has a reputation for miss-classifying workers.

Wage Rate Interviews

Wage rate interviews serve as a final check for the certified payroll. Wage rate interviews are conducted on the job site with randomly selected workers. The workers are asked how much they are paid and how many hours they worked. Often the workers tell inspectors that they do not know their wage rates. This may be due to the fact that they have recently moved from an area where the minimum wage is different or they change job classifications often. The inspector usually responds to these situations by telling the workers where the wage rates are posted. No recommendations were made for improving the wage rate interview process. Because many workers do not know the minimum wage rates, the difficulty of enforcing the minimum wage rates is increased.

TRUCK TICKETS

It is important to document proof of delivery when a transportation agency is paying for materials by weight that are delivered by truck. Examples of such materials are asphalt, aggregate base, and granular surfacing. Traditionally, the Project Engineer's field staff documents proof of delivery by collecting truck tickets at the location where the materials are placed. This activity ensures the materials are actually incorporated into the construction project. The concern is that the transportation agency will be charged for

materials that are not produced or for materials that are diverted to other construction projects. Federal regulations require collection of truck tickets for federal aid projects unless an alternative arrangement is approved by the division administrator (23 CFR 635A, p19 and NS CFR 635A Federal Aid Policy Guide, April 22,1994, Transmittal 10). The Iowa DOT Office of Construction has not made such an alternative arrangement.

As the field staff has been reduced, it has become increasingly difficult to assign a staff person to collect truck tickets and compromises have been made. The Iowa DOT Construction Manual allows contractors' employees to collect truck tickets for asphalt paving operations if they are placed immediately on a clipboard in view of the field staff. The review committee provided anecdotal evidence that contractors' employees collect truck tickets in many other cases because the Project Engineer's staff is placing higher priority on other inspection activities.

It would be desirable for transportation agencies to negotiate an alternative arrangement with the FHWA division administrator that will provide reasonable protection to the transportation agency but reduce staffing requirements. During discussions with the review committee, ISU researchers developed a list of possible alternatives for further consideration:

- Automatically record deliveries using:

  a) Digital camera images that show the truck and date and time of delivery. The camera could be mounted on the paver and automatically tripped when the truck makes a delivery.

  b) Radio frequency identification (RFID) tags mounted on trucks and read by mobile units on the paver or other location near the point of delivery. The RFID tags could be encoded to provide the truck number, weight of material and type of material. The information could be time stamped and stored by the reader unit in a data base. The data base could be downloaded and reviewed periodically.
- Trucks could be tracked by Global Positioning Systems to make sure material is not being diverted away from the project.

- Conveyor belt scales could be placed on the paver to provide a rough check with tickets collected by people other than the Project Engineer's staff.
- The Project Engineer's staff could conduct unannounced intensive investigations of delivery operations to audit contractor activities. Significant penalties could be used to discourage violations.
- For certain operations, it may be possible to double check deliveries by examining in place materials and partially monitoring the delivery operation.
- Ticket collection activities could be reduced in situations where little opportunity exists to divert loads.

Discussions regarding ticket collection occurred near the end of the research project. The review committee and the Office of Construction decided to concentrate efforts in completing research on other aspects of field data collection and reporting system. Therefore, this portion of the study ended after these alternatives were listed.

FLOW CHARTS FOR OTHER PROCEDURES

Several procedures are documented in Chapter Two of the Iowa DOT Construction Manual. Most of this documentation consists of narratives. Flowcharts are also available for many procedures. During discussions, review committee members expressed a desire to develop flowcharts to accompany most of the narratives. They felt that the flowcharts would help employees learn and recall the procedures more efficiently. Several field staff people will be retiring soon and this will make it necessary for the people moving into these positions to learn the procedures quickly. The review committee also pointed out the need for experienced staff to quickly recall procedures that are not used on a regular basis. The following procedures were flowcharted:

- Change orders
  - Classification between Substantial and Nonsubstantial (several flowcharts required)
  - Substantial Primary
  - Nonsubstantial Primary

- Local Systems

- Temporary Stream Crossings
- Permanent Stream Crossings
- Work Day Reports

  - Primary

  - Local Systems
- Contractors' Evaluations
- Primary Stormwater Discharge
- Haul Road Designation
- Haul Road Revocation
- Pile Driving Log
- Certificate of DBE Accomplishment

During review committee meetings in October 1996, November 1996, December 1996, January 1997 (two meetings) and February 1997, ISU researchers facilitated discussions to develop the flowcharts. Initially draft flowcharts were developed. These draft flowcharts were reviewed during subsequent meetings and changes were made that would improve information flow and simplify procedures. Particular attention was paid to the distribution of copies and the level of approval authority. The flowcharts have been delivered to the Office of Construction on a computer disk so they may be incorporated in the 1998 Iowa DOT Construction Manual. The decision was made to wait to include the flowcharts in the 1998 revision because the narratives must be rewritten to reflect improvements made during the flowcharting process. Rewriting the Iowa DOT Construction Manual is outside the scope of this project. The review committee is currently working to rewrite Chapter 2 of the Construction Manual. They are also updating it with changes that result from the use of the Electronic FieldBook computer program.

JOB CLOSE-OUT

The researchers and the review committee reviewed the job close-out package. This is a group of documents that are submitted at the end of a contract to show that proper quality control and quality assurance procedures have been followed and that contractor payments are appropriate. The complete close-out package as it existed at the beginning of the project is described in Appendix A. As a result of recommendations from researchers, two of the items were eliminated. Changes are being considered to eliminate a third item.

List of Non-substantial Change Orders

Non-substantial change orders are documented elsewhere in the file. Therefore, this list was redundant. The FHWA representative in the review committee said that this list is not required by the FHWA. The researchers and the review committee recommended that the list should be eliminated. The Office of Construction acted on the recommendation and eliminated the list from the close-out package.

Overrun/Underrun Statement

This statement was originally required by the Office of Finance and the FHWA. It was used to prove that the original contact amount modified by extra change orders overruns, and underruns of bid quantities were equal to all of the payments to the contractors. The FHWA representative on the review committee stated that this list was no longer an FHWA requirement. Discussions with the Office of Finance revealed that the statement could not actually be used to prove that the payments to contractors were correct. This is because not all changes in bid item appeared on this statement. Small overruns and underruns are not documented by change orders. Discussion also revealed that the Project Engineer and Transportation Center audits provide sufficient safeguards against mistakes in calculating contractor payments. Since this list did not serve its intended purpose, the Office of Construction, Office of Finance, and FHWA agreed to eliminate this list from the close-out package.

Contractor's Statement of Sales or Use Tax (181321)

Review committee members indicated a strong desire to eliminate or modify this procedure. The form requires contractors to list the amount of sales tax expended for permanent materials that were incorporated into the project. The Iowa DOT submits this to the Department of Revenue so that it is reimbursed for the amount of the tax. In essence, this allows the Iowa DOT to purchase permanent materials without paying sales tax. The contractors have little motivation to complete the form in an accurate and timely manner because they gain no direct financial benefit. Late submission of this form by the contractor often delays job close-out and final payment.

In 1995, Governor Branstad appointed a Blue Ribbon Task Force (BRTF) to develop ideas for increasing the efficiency of the Iowa DOT. At the beginning of the study, the task force asked for ideas to help them meet their goal. Recalling the discussion during the review committee meetings, one of the review committee members, Donna Buchwald, submitted a written suggestion through the Office of Construction that this procedure should be simplified. The BRTF adopted this suggestion. As a result, the BRTF has recommended a method whereby the sales tax expenditures could be electronically estimated as a percentage of various bid item unit prices. Using these estimates the Department of Revenue could reimburse the Iowa DOT without form 181321. The Iowa Assembly passed legislation (HF 704) to make the required changes to the *Iowa Code*.

SUMMARY OF ACCOMPLISHMENTS

This project resulted in several major accomplishments and many minor ones. The entire field data collection and recording systems for ACC paving, PCC paving and PCC structures were streamlined and computerized. The field procedures for materials acceptance were also reviewed. Best practices were identified and a method was developed to prioritize materials so transportation agencies could focus their efforts on high priority materials. ISU researchers facilitated discussion of EEO/AA procedures between the review committee and the Office of Contracts. A set of alternative

procedures was developed. Later the Office of Contracts considered these alternatives as they developed new procedures that are currently being implemented. The job close-out package was reviewed and three unnecessary procedures were eliminated. Numerous other procedures were reviewed and flowcharted. Minor changes were made to streamline the procedures and increase consistency between offices. The flowcharts will be incorporated into future editions of the Iowa DOT Construction Manual.

The project met its objectives as explained below:

1. Eliminate needless paperwork so that employees can concentrate on higher priority tasks

Revisions to ACC paving, PCC paving, and structural concrete procedures greatly reduced the number of entries inspectors have to make on the forms. Entries for ACC paving were reduced by 55% and PCC paving by 42%. The use of electronic spreadsheets will result in additional time savings. After discussions held as part of this project, the Office of Contracts developed new procedures that greatly reduced the number of EEO interviews. Three items of needless paperwork were eliminated from the job close-out package.

2. Provide time-sensitive information on a timely basis

Quality assurance information for asphalt and concrete paving plants is now provided to the Transportation Center Materials Engineer (TCME) the day after the material is produced instead of several days later. This allows the TCME the opportunity to recommend adjustments quickly.

3. Standardize procedures between offices

All of the procedures recommended under this project were reviewed by the Senior Construction Technician from each Transportation Center. ISU researchers made field visits to various parts of the state to observe different practices and select the best

ones. The procedures have been documented in flowcharts for inclusion in future editions of the Iowa DOT Construction Manual. These actions will encourage standardization.

4. Centralize storage of information

One EEO/AA policy per contractor is now filed with the Office of Contracts. Previously a separate policy had to be submitted for each project.

5. Develop procedures that are compatible with the future computerized improvements

Computer spreadsheets were developed for use with ACC and PCC paving procedures. These spreadsheets could serve as a data collection tool for AASHTO's SiteManager when it is implemented. Researchers developed consistent titles for entries. This will facilitate the use of data bases to store information from the spreadsheets. The investigation on best practices for field procedures for materials acceptance documents influenced the development of AASHTO's SiteManager.

6. Develop procedures that can be reviewed regularly and updated easily

The flowcharts developed for many procedures are easily understood and narrative material explains why recommendations were made. These can guide discussion when changes are contemplated. The materials classification system can be modified as changes occur in manufacturing uniformity, and the influence that materials have on safety and economic performance. A new expert survey may be conducted to revise the rating.

7. The final report should be written so that it can be used as an orientation aid

Portions of the final report have been incorporated into training materials for asphalt and concrete plant procedures. Narratives on materials acceptance policy and job close-out could be incorporated into other training materials. Flowcharts that are not included in this final report will appear in future editions of the Iowa DOT Construction Manual.

Several changes have been recommended that will increase efficiency and allow staff time to be devoted to higher priority activities. It is estimated the improvements in

ACC paving, PCC paving and structural concrete will be equivalent to three FTE positions to the field construction, field materials and Office of Materials. Elimination of EEO interviews will be equivalent to one FTE position to the field construction. It is estimated that other miscellaneous changes will be equivalent to at least one other FTE person. This is a total of five staff positions. These are conservative estimates based on savings that are easily quantified. It is likely that the total positive effect is greater when items that are difficult to quantify are considered.

APPENDIX A - CLOSE-OUT ACTIVITIES

When a job is completed, several documents must be submitted as a job close-out package. The entire close-out package was reviewed as part of the project. Table A1 shows the close-out package as it existed in the 1994 Construction Manual. This was the current Construction Manual at the beginning of the project. The results of the review of each item are provided below. Iowa DOT form numbers are shown in parenthesis.

Project Acceptance (830435) and Final Payment (830436) — The Project Acceptance form (830435) is issued by the Project Engineer within five days after project completion. It indicates that the contractor has completed the work. This form should not be held up because material acceptance documents or change orders are not complete. The Final Payment Form (830436) authorizes the Office of Finance to issue the final payment to the contractor. It is issued when all documentation is complete including material acceptance documents and change orders. In signing this form, the Project Engineer certifies that all materials have been tested and found in reasonably close conformity with project specifications or that appropriate price adjustments have been made.

The researchers and review committee considered the possibility of combining these two forms. This was not possible because the forms are used to document two important points in time: project completion in the field and final payment. When form 830435 is executed, it indicates the project has been accepted and that claims by subcontractors and suppliers for nonpayment by the prime contractor must be filed within thirty days.

Form No	Description
830436	Final Payment
None	* Statement of Noncomplying Test of Measurement of Materials Incorporated into the Project
FHWA-47	* Statement of Materials & Labor (required for contracts greater than $ 1,000,000.)
181321	Contractor's Statement of Sales or Use Tax (Cities will file directly)
181317	* Statement of Freight Rates (Required for contracts greater than $50,000)
830240	* Final Extra Work Order
830235	Interest Payment Information
None	* List of Non-substantial Extra Work Orders
181013	Contract Construction Progress Voucher (May be Universal Payment Voucher Form 181001 on certain types of projects)
830301	Audit of Final Pay Estimate
None	Overrun/Underrun Statement
None	* Summary of City or County Reimbursement for Reimbursement Work
181201	* Reallocation of Accounting Units (Used for splitting costs between counties or funding types, state projects)
181202	* Quantity Reallocation for Final (Used for splitting costs between counties or funding types, state projects)
None	* Statement of Salvage Material
133006	* Return to Stock
102116	* Certification of DBE Accomplishment
650032	* Consultant Performance Evaluation

* When applicable

Table A1.1 Job Close-out Package in 1994

The date of form 830435 is also important for calculations of interest on retainage. The *Iowa Code* requires the Iowa DOT to pay interest on all retainage from the time that it is first retained until ninety days after the completion of the project. Retainage is paid with the final payment authorized by form 830436. The final payment cannot be made until all material acceptance documents are in order and all change orders have been executed. Therefore the ninety days after project completion serves as a grace period for the contractor to receive interest on retainage while missing materials acceptance documents are found and final change orders are negotiated. Since the date on form 830435 marks the beginning of the grace period, retaining the form is important.

After careful review, no changes were recommended for forms 830435 and 830436.

Statement of Noncomplying Test of Measurement of Materials Incorporated into the Project — This document is required to list any deficiencies in that material testing program for the project. The document also states how the deficiency was resolved (e. g., a price adjustment). It is recommended that this document be retained.

FHWA-47 — This form is required by FHWA for all contracts greater than $1,000,000. It provides raw data that is used by the FHWA to provide transportation agencies with conceptual cost data for future contracts. After researching the FHWA representative on the review committee indicated that this form cannot be eliminated.

Contractor's Statement of Sales or Use Tax (181321) — This form requires contractors to list the amount of sales tax expended for permanent materials that were incorporated into the project. The Iowa DOT submits this to the Department of Revenue so that it is reimbursed for the amount of the tax from the General Fund to the Road Use Tax Fund. In essence, this allows the Iowa DOT to purchase permanent materials without paying sales tax. This form will be eliminated by the passing of HF 407 by the Iowa Assembly.

Statement of Freight Rates (181317) — This form was eliminated when section 1109.08 was struck from the *Iowa DOT Standard Specifications for Bridge and Highway Construction.* This research project was not involved in this process.

Final Change Order (830240) — This indicates that all change orders must be resolved before the project is closed-out. No changes are recommended to this policy.

Interest Payment Information (830235) — The Office of Finance needs the information on this form to calculate the interest payments on retainage. No changes are recommended for this form.

List of Non-substantial Change Orders — This list was eliminated from the job close-out package in 1996 by order of the Office of Construction with concurrence with the Office of Finance and the FHWA.

Construction Progress Voucher (181013 or 181001) — Voucher is required to make the final payment and cannot be eliminated.

Audit of Final Payment (830301) — This documents the audit of the final payment voucher by the TCME. It is recommended that this form be retained.

Overrun/Underrun Statement — This statement was eliminated from the job close-out package in 1996 by order of the Office of Construction with concurrence with the Office of Finance and the FHWA.

Summary of City or County Reimbursement — This summarizes the amounts that local jurisdictions have reimbursed the Iowa DOT for construction provided at the request of the local jurisdiction. Often, local jurisdictions will ask the DOT to include some of

their construction on larger contracts to gain economies of scale and reduce administrative costs. This documents the necessary reimbursement. No change is recommended.

Reallocation of Accounting Units (181201) and Quantity Reallocation for Final (181202) — These forms are used to show the amount of transportation construction expenditures within various local jurisdictions. They are used on projects that cross county or city lines. Among other things, these forms provide expenditure breakdowns between urban and rural areas and among legislative districts which is a requirement of the *Iowa Code*. No changes are recommended for these forms.

Statement of Salvaged Material — Occasionally the Iowa DOT retains ownership of material that is salvaged from a project site by contractors. When this happens, the disposition of the salvaged material is documented here. This statement is seldom included in the close-out package. However, it is important to include it when it is required. Therefore, it is recommended that this statement be retained.

Return to Stock — Occasionally the Iowa DOT requires contractors to install items that the DOT stocks in its warehouse. When the entire quantity is not installed, the items must be returned to the warehouse. This form documents the return. Although seldom used, it satisfies an occasional need. Therefore, it is recommended that this form be retained in the close-out package.

Lance A. Elliott, Charles T. Jahren, Michael J. Halbur

Field Data Collection and Reporting Study: Section II ACC and PCC Paving and Structural Projects

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Iowa Department of Transportation

report

FINAL

Deparment of
Civil and Construction Engineering
Iowa State University

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ABSTRACT

A review of the Iowa Department of Transportation field data collection and reporting system for asphalt cement concrete paving, portland cement concrete paving, and portland cement concrete structures has been performed. The Iowa Department of Transportation has not recently had a thorough review of the information flow for these projects. Users of the system have expressed concern about many inefficiencies and have indicated great potential for improvement. Among the inefficiencies mentioned are excessive recopying, timely information not delivered on a timely basis, inconsistent terminology, and people located in different places filling out the same forms. The path of information was traced from its source to its end users. Information needs were divided into categories of project administration, process monitoring, and paving histories. The needs were analyzed and a revised field data collection and reporting system was developed in which time-critical process-monitoring information is separated from non-time critical information. Requirements for copying information have been reduced, which will result in personnel needing less time to complete paperwork and will allow more time for inspectors to concentrate on other tasks. The proposed system eliminates the current daily plant reports and replaces them with loose-leaf field notebook pages that may be copied or faxed to transmit information to other users. The system has been reviewed and approved by personnel from several state and local systems and has been designed to be compatible with future automated systems.

INTRODUCTION

The Iowa Department of Transportation (Iowa DOT) and the counties and cities within Iowa perform many construction administration functions for publicly funded construction projects. To administer a complete construction project from the design stage until final payment to the contractor, personnel must coordinate efforts and exchange great amounts of information. Project information is needed for process monitoring, project administration, and paving histories. These three information needs have unique information gathering and reporting requirements. A standardized system that accommodates these requirements is essential for providing an efficient flow of information.

This section of the report focuses on collecting and reporting information on construction projects that contain asphalt cement concrete (ACC), portland cement concrete (PCC) paving, and PCC structures. Since these projects constitute a very large portion of highway construction work, they require a large amount of record keeping. Improving these areas will yield great returns.

Many forms and field book pages must be completed and reviewed during a typical day of production. Most of this information is collected and recorded at the point of placement (the grade) or at the plant and recorded on standardized paper forms. These forms are reviewed, distributed, and compiled along with other project information and kept for future reference.

The current manual system of recording and reporting this information has many inefficiencies:

1. Excessive recopying (duplication) of the same information from one form to another
2. Requiring people working at different locations to record information onto the same form
3. Different offices having different requirements for the same type of construction
4. Nonstandard procedures for collecting and reporting information among Iowa DOT residencies and transportation centers, counties, and cities
5. Time critical information not getting to users on a timely basis
6. Losing important information in unimportant information
7. Misunderstandings regarding what information is required and how important it is

8. Inconsistent terminology.

Planning must by undertaken to allow conversion from the current manual system to future automated systems. The American Association of State Highway and Transportation Officials (AASHTO) is developing the construction management system SiteManager, a comprehensive construction management computer program sponsored by a consortium of state transportation agencies including the Iowa DOT. Its primary purpose is to enable construction project personnel to more effectively and efficiently document compliance with construction contract provisions and enable personnel to spend more time with monitoring and testing duties. SiteManager will perform the following functions:

- Project record keeping and daily work reports
- Voucher processing and finalization
- Materials management
- Monitoring civil rights requirements
- Construction administration, including
    - Change order processing
    - Claims tracking
    - Document management

In order to take advantages of such a system, the Iowa DOT must clearly define its field data collection and reporting system. This is essential for a smooth transition. The inefficiencies listed previously must be resolved before the SiteManager system can be successfully implemented.

This project addresses these issues and the results will provide the necessary tools to assist in improving the current field data collection and reporting systems and facilitate the development of the SiteManager system in the areas of ACC and PCC paving and PCC structures. Much of the information that the computer programmer needs will be provided.

RESEARCH METHODOLOGY

A review committee was formed during the fall of 1994 with the following membership (See Appendix A for complete list):

- Iowa DOT Senior Engineering Technicians from each regional transportation center
- An Iowa DOT Office of Local Systems representative
- A county engineer representative
- A Federal Highway Administration representative
- Iowa State University research students
- A Transportation Center Materials Engineer

The committee was guided by Iowa State University Professor Charles T. Jahren, Principal Investigator of the project, and Donna Buchwald, Iowa DOT Field Systems Engineer. The first meeting was held in January 1995. Monthly meetings were held thereafter. Many additional Iowa DOT personnel attended the meetings during the course of the study.

Detailed Objectives and Priorities

During the first data collection and reporting meeting, the review committee developed seven detailed objectives and priorities to serve as a guide for the ISU research team:

1. Eliminate needless paperwork so that employees can concentrate on higher priority tasks
2. Provide time-sensitive information on a timely basis
3. Standardize procedures between offices and identify the best procedure possible for each task
4. Centralize storage of information (where appropriate)
5. Develop procedures that are compatible with future computerized improvements
6. Develop procedures that can be reviewed regularly and updated easily
7. Write a final report that explains suggestions and can be used to aid implementation.

After developing the objectives and priorities of the study, the review committee agreed on a number of areas concerning data collection and reporting that needed a detailed review. Among the topics suggested were ACC and PCC paving and PCC structures reports, Equal Employment Opportunity (EEO) and Disadvantaged Business Enterprise (DBE) compliance regulations, trainee programs, finalization process, and the material certification process.

ACC and PCC paving and PCC structures were selected for analysis in the initial portion of the study. The results of that analysis are reported here. The other topics are currently being analyzed. The results of those analyses will be reported in the final report. The research methodology is described in greater detail in the following sections.

Information Gathering

Along with the monthly review committee meetings, the ISU research team visited the six Iowa DOT Transportation Centers, 13 of the 20 residency offices, 2 county engineers, 1 city engineer, several paving and structural construction projects, and 3 ready mix plants (see Appendix C for a complete list of field trips). Many interviews were conducted during the field trips. The interviews provided insight from many different perspectives. Additional interviews were conducted with several employees of the Office of Construction and the Office of Materials in Ames, Iowa (see Appendix B for complete list of interviews).

The ISU research team reviewed the Iowa DOT 1992 Specifications, the Office of Materials Instructional Memorandums (I.M.s), the Construction Manual, and all of the forms required for ACC and PCC projects, including the information needed for auditing purposes and paving histories. Published literature on information management and components of ACC and PCC was also reviewed.

The information gathered during the information gathering activities was reported to the review committee at the monthly meetings and was used for defining the proposed data collection and reporting procedures for ACC paving, PCC paving, and PCC structures projects. A detailed description of the analysis is covered in the next section.

Recommendations and Implementation

This report provides the Iowa DOT and Iowa counties and cities with final recommendations for improving the field data collection and reporting procedures for ACC paving, PCC paving, and PCC structures projects.

The Iowa State research team assisted in the implementation and training processes. The initial implementation consisted of a pilot study during the 1996 construction season. The research team attended and participated at training work shops and various Iowa DOT and county information meetings. Field visits were made to help facilitate a smooth transition. Training aids were also developed to assist in the implementation.

The final revisions have been made and full implementation is planned for the 1997 construction season. New Instructional Memorandums (IMs) have been written to accommodate the new systems.

ANALYSIS

After receiving comments and suggestions from the review committee, the ISU research team performed a detailed analysis of the field data collection and reporting system. This analysis consisted of identifying all the information to be gathered and systematically defining the requirements for gathering and transmitting the information. The analysis of this project can be broken down into four steps.

The first step of the analysis was to study the Iowa DOT, county, and city organizations and understand the function of each office, the responsibilities of the personnel, and the relationships between offices.

The second step was to define the different uses of the information. The uses of the information collected during a typical ACC or PCC project can be divided into three categories: administrative information, process monitoring information, and paving history information. Each of the three categories must be examined to determine all of the uses of the reported information.

The third step was to trace each piece of information from its source to its ultimate destination and identify each information user along the path.

The final step was to design a revised field data collection and reporting system for ACC paving, PCC paving, and PCC structures.

Iowa DOT And Local Systems: Construction Information Relationship

The Iowa DOT and local systems (counties and cities) consist of many offices that have a wide variety of duties. The focus of this report will be on the offices which are directly affected by this study. These include: Office of Construction, Office of Materials, the six transportation centers, the twenty resident offices, and numerous local systems offices. Local systems offices are involved when local construction projects are federally funded (Figure 1).

Two offices in the Iowa DOT Project Development Division are primarily affected by this study: the Office of Construction and the Office of Materials. The Office of Construction is responsible for administering Iowa DOT construction projects. Construction projects are administered by the six Transportation Center Construction Engineers (TCCEs). The TCCEs

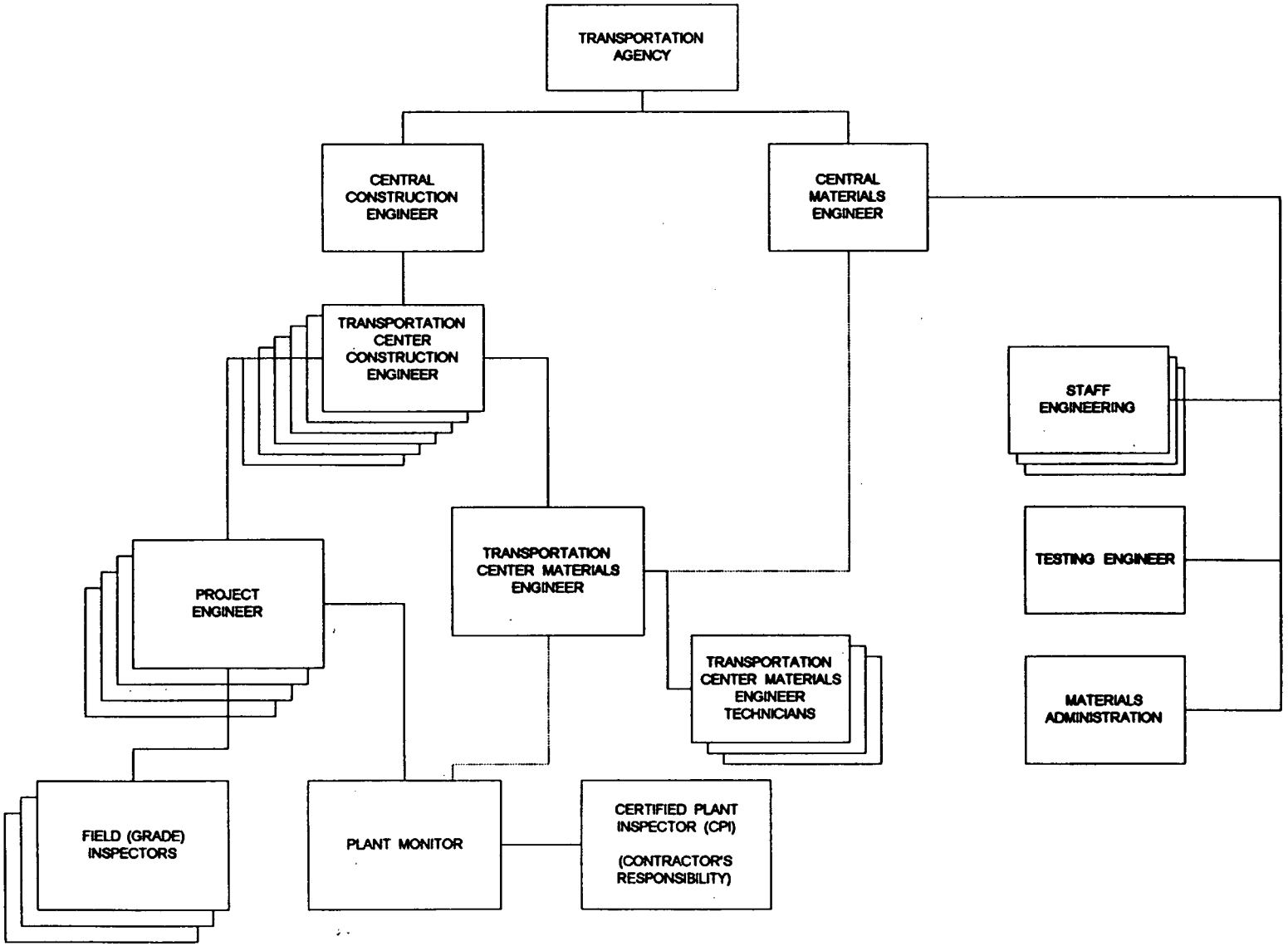

Figure 1. Transportation Agency Organization: The Iowa DOT

supervise the Transportation Center Materials Engineer (TCMEs) and Resident Construction Engineers (RCEs), and conduct field reviews of construction projects to evaluate the progress and quality of the work performed.

The RCE is ultimately responsible for administering Iowa DOT construction projects on the primary and interstate systems. County and city engineers are responsible for local systems projects. City and county engineers provide certain information on state and federally funded projects to the Iowa DOT local system office through the Transportation Center. Resident Construction Engineers, city engineers, and county engineers are referred to herein as Project Engineers.

The Project Engineer has authority to supervise and administer construction contracts in accordance with plans and specifications and to assign inspection personnel to construction projects. The Project Engineer delegates most of the everyday activities to one or more experienced employees (field or grade inspectors and plant monitors). Field Inspectors are responsible for assuring that all materials furnished and work performed by the contractor are in compliance with contract requirements, making complete computations, and recording required documentation of inspected work. They document pay quantity and other general information in the project's loose-leaf notebook. The loose-leaf notebook contains pages for each pay item. These pages are updated daily and used for preparing pay vouchers.

The Plant Monitor is responsible for inspecting stockpiles, plant facilities and equipment, auditing the Certified Plant Inspector's (explained below) documentation, and testing the first three contractor tested samples of each aggregate or ACC mix design and a minimum of 10% of the remaining sample.

Iowa DOT, county, or city personnel are also responsible for witnessing core sampling and performing density tests on asphalt concrete paving projects, witnessing flexural beam tests on PCC paving projects, and testing flexural beam tests on PCC structures projects.

The Certified Plant Inspector (CPI) is provided by the contractor. The CPI is responsible for performing necessary batch calculations, inspecting the plant and materials, being present while the plant is in operation, and recording and reporting documentation. Most of the information is recorded in the project's plant book. This is a loose-leaf notebook that contains pages to document plant and material information.

The Function of the TCMEs include: project auditing, quarry inspections, bituminous mix design, project reviews, contractor monitoring materials approval, and assurance testing. Most of these functions are performed in close consultation with the Central Office of Materials.

The Central Office of Materials provides expertise to ensure that construction materials meet quality requirements. This office has a Materials Engineer who supervises three Staff Engineers (Bituminous Engineer, PCC Engineer, and Structural Materials Engineer), a Testing Engineer, and a Materials Administration group. The Staff Engineers are users of the field data collection and reporting system. They respond to process monitoring problems that are brought up by the TCMEs. They are also involved with entering and reviewing paving histories.

The Testing Engineer supervises a staff of engineers and geologists who test materials within the Central Laboratory. The Testing Engineer also serves on quality improvement committees and recommends specification revision.

The Materials Administration is responsible for project auditing. Therefore, they are also users of information from the field data collection and reporting system. Because Materials Administration organizes the training program, their involvement will be necessary in the implementation stages of this project.

All of these offices and personnel must coordinate activities and exchange information efficiently to complete their tasks and fulfill their responsibilities successfully. The next section discusses some of these duties in more detail to assist in the explanation of the proposed systems. A complete definition of these inspector's duties and responsibilities can be found in the Iowa DOT Construction Manual and Office of Materials IMs.

Categorization of Information Uses

The information collected during a PCC or ACC project can be divided among the following three uses: administrative, process monitoring, and paving histories (Figure 2). The administration function is important for correctly paying the contractor for the amount of PCC or ACC placed; completing audits to verify amounts of materials used; and assuring that the

correct number of process control, acceptance, and assurance tests were performed. The process monitoring function is important in assuring that the concrete continually meets the appropriate standards and that it was placed correctly. The histories are important for current and future reference to ensure that the materials perform satisfactorily and may be expected to perform well on future projects. Each of the three categories will now be discussed in more detail.

Administration	Process Monitoring	Paving Histories
• Progress Payment • Materials Audit • Action on noncompliance	• Plant information (CPI) • Grade information (Grade Inspector) • TCME review	• History forms filled out by TCME • Computerized data base • Pavement management system

Figure 2. Field information

Administrative

Information is collected in the field that addresses issues of contractor payment (pay quantities), incentives, penalties, and progress of the project that provides the Office of Contracts and Office of Accounting with information needed to accomplish their tasks. Information is also needed by the residencies, transportation centers, and Office of Materials for conducting a complete audit by the end of the project.

Since some of this information is needed while the construction project is being constructed and other information is not needed until after the project has been completed, the reporting of this information can be separated. For example, during the project, pay quantity information is recorded by the field (grade) inspector in the loose-leaf field book. This information is used to generate pay vouchers every two weeks for progress payments to the

contractor. Pay quantities are usually measured by square yards for paving projects and cubic yards for structural projects.

On the other hand, the information needed at the end of the project for administrative and auditing purposes include: material deliveries, field documentation, and final pay quantities. The first step of the auditing process consists of the Project Engineer's pre-audit (PEP). This is an ongoing process of accumulating documents, reviewing them for completeness and accuracy, and documenting the resolution of any outstanding noncompliance issues. Ideally, most of this activity occurs during the project; however, a few of these items must be completed at the end of the project.

The second step is the TCME audit. This is conducted when the PEP is completed and the final voucher is ready to be forwarded for processing. It includes a review of internal office controls, procedures, and documentation; material certifications and test approvals; field documentation; internal office audit; and final pay quantities.

The third step consists of the Office of Materials checking the completeness of the audit, verifying noncompliance actions, and signing off for final payment to the contractor.

Materials Process Monitoring

Inspection is the primary function of process monitoring. This function includes inspection of both materials and construction techniques. In general, inspection is provided to ensure that the contractor uses quality materials in the correct manner to provide a quality product for the public's use.

The Iowa DOT and some local systems have recently moved in the direction of allowing a contractor's employee or representative, who is certified by the Iowa DOT, to have control of the production (plant operations). This person is referred to as the certified plant inspector (CPI). The CPI is responsible for the quality control of the material produced and documents important material information. A plant monitor, an Iowa DOT, county, or city employee, monitors the plant periodically and audits the work of the CPI. The field inspector inspects the work at the point of placement. With these changes in philosophies, it is even more important to define responsibilities of public employees and determine the levels of checking needed to assure that the correct materials are used in the correct proportions.

Information for process monitoring is collected and reported during the project. It is important that this information be reviewed as soon as possible so that quick action may be taken if material problems are detected. As mentioned earlier, the CPI is present at the plant during production and continually inspects the raw materials. The plant monitor inspects the plant on a less frequent basis and monitors the work of the CPI. The most critical items that affect the quality of concrete are also reviewed by the TCME.

The frequency of reporting the process control information to the TCME differs between paving and structures projects. The ACC and PCC paving projects generally place large amounts of concrete on consecutive days. If something is awry, large amounts of inferior concrete could be placed if the problem is not quickly detected. Therefore the TCME should review this information on a daily basis. Typically, the pours for PCC structures are smaller and not as continuous in nature. A weekly review by the TCME appears to be adequate.

Flexural beam specimens tests are conducted for all PCC projects. On paving projects, the Grade Inspector makes the beam and the CPI cures and tests the specimen. On structures projects the structures inspector makes and tests the specimen that was cured by the CPI. These tests are very important for making decisions in the field pertaining to stripping forms, backfilling, or opening to traffic. The strength of the newly placed PCC must reach appropriate levels before these activities can proceed. The beam test information is also reviewed to ensure that PCC of adequate strength is produced. This information will be reported to the TCME on a weekly basis. The TCME may use this information for detecting trends and comparing the strength of various mix designs.

Histories

The Iowa DOT currently prepares history reports for ACC and PCC paving projects. Paving histories contain general information such as locations placed, mix type, material sources, mix design and test data, changes in mix design, and aggregate gradations.

The purpose of paving histories is to provide quick access to important information that may reveal the possible causes of pavement failure. If problematic materials or mix designs are detected, corrective action can be taken. Paving history information also supplies

designs are detected, corrective action can be taken. Paving history information also supplies information to the pavement management system, a database of pavement information which is used to monitor the highway system and predict future maintenance needs.

Paving history information is not needed until after the paving portion of the project is completed. This information is generally obtained from the project files. The TCME is responsible for initiating the paving history reports and for maintaining one file at the Transportation Center. One copy forwarded to the Office of Materials for the central files.

Tracing Information Flow

The next step of the analysis was to study each piece of information to determine when and where it is recorded and reported. Information flow was traced from its source to its ultimate destination, and each user was identified along the path. Each piece of information on every form was analyzed.

Designing Each System

The final step was to design a revised field data collection and reporting system. Several alternative systems were developed. These alternatives were presented to the review committee and the preferred alternative was further refined. Sample forms were taken on field trips and presented to interviewees. After numerous refinements, the proposed systems presented in this report were developed.

PROPOSED REPORTING SYSTEMS

The proposed field data collection and reporting system for each of the three types of projects will now be described in more detail. PCC paving and PCC structures will be explained together since they share many of the same components. To minimize the amount of repetitiveness, topics similar to all three types of projects will simply be referred to when describing the ACC paving system.

PCC Paving and PCC Structures

A typical PCC paving project uses a central mix plant to supply PCC for the project. The PCC is usually transported by dump trucks to the paver. A central mix plant is typically a mobile plant which is set up and operated by the contractor near the location of the project. While in operation, the plant solely provides the paver with a constant supply of PCC.

A ready mix plant is generally used for supplying PCC to smaller urban paving and most PCC structures projects. It is typically a stationary commercial plant that supplies PCC by ready mix trucks to various private, federal, state, and county projects. The distance between the plant and project can range from a short distance to many miles. It is important that the concrete is placed within a specified time period. Process monitoring is an important role in ensuring high-quality concrete. The CPI continually monitors the production of concrete for each placement, and the plant monitor periodically checks the CPI's activities and the operation of the plant.

An on site mobile mixer is commonly used for bridge deck overlay pours. It is typically a small truck mounted unit that mixes PCC at the project site. The materials are generally stockpiled at the site. A mobile mixer is equipped with a recording water meter and a cement meter. This can be used to calculate the water/cement ratio of the mix with reasonable accuracy.

Under the current system, most information is transmitted by Form 830224 *Combined Daily Inspection Report of Portland Cement Concrete* (Figure 3) on paving projects and Form 830211 *Weekly Concrete Report* (Figure 4) on PCC structures projects. These forms contain time-sensitive process-monitoring information along with non-time sensitive administrative

Form 830224(E)
4-94

COMBINED DAILY INSPECTION REPORT OF PORTLAND CEMENT CONCRETE PAVEMENT

Contract No. _____ Contr. _____ Res/Co. Engr. _____ Project _____ County _____

Report No. _____ Date _____ Date of Last Report _____ Plant Owner and Location _____ Sq. Yards (Cont. Qty.) _____

Weather _____ Days Temp. Max _____ Min. _____ Min. Temp. Foll. Night _____ Plant Insp. _____ Cert. No. _____

Item/ Lane	STATION From	STATION To	Length Feet	Sq. Yards	CU. YDS. Est.	CU. YDS. Batched	CU. YDS. Used	% of Est Used	Time Start / End	Mix No.	DRY BATCH WEIGHTS F.A.	DRY BATCH WEIGHTS C.A.	MOISTURE CONTENT F.A.	MOISTURE CONTENT C.A.	ACTUAL QUANTITIES USED PER CU. YD. (IN POUNDS) Cement	Fly Ash	Fine Aggr.	Coarse Aggr.	Water in Mat'ls.	Water Added at Plant	Water Added at Grade	Total Water	Slump	Air	Hand Fin.
									/																
									/																
									/																
									/																
									/																
									/																
TOTAL ▶																									
PREVIOUS TOTAL ▶																									
TOTAL TO DATE ▶																									

Total Cement Batched _____ Total Fly Ash Batched _____ Total Water _____

Maximum Allowable Water _____ Brand of Air Admixture _____ Ave. Water/Cement _____

Calcium Chloride ☐ Yes ☐ No Max. Water/Cement _____

Water Reducer ☐ Yes ☐ No Brand _____ Normal Batch Size _____

Source:

Fly Ash _____ Sp. Gr. _____

Fine Aggr. _____ T-203 No. _____ Sp. Gr. _____ Plant Test _____

Coarse Aggr. _____ T-203 No. _____ Sp. Gr. _____ Plant Test _____

Certified Aggregate Verification Coarse Aggr. Durability _____

Fine aggregate _____ tons Coarse Aggregate _____ tons

Time Lost And Cause _____

Type of Subgrade _____

CEMENT Brand	Type	Ticket No.	Amount Tons
FLY ASH			

Method of Curing

Texture Method

BEAMS MADE Time	Beam No.	Slump	Air

Method of Covering Subgrade
☐ Plastic ☐ Moistened
☐ Slip Form ☐ Fixed Form

Method of Mixing
☐ Central Mix ☐ Transit Mix

Cold Weather Protection ☐ Yes ☐ No

BEAMS TESTED Beam No.	Mix No.	Age Days	Depth inches	Width inches	Slump	Air	Ind. Load	Act. Load	Computation Factor	Mod. of Rupture	Location of Break

Sample I.D.	Grad. No.	AGGR SIEVE ANALYSIS PERCENT PASSING 1½ IN	1 IN	¾ IN	½ IN	⅜ IN	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	COMP.

Additional Slump, Air Tests, Remarks _____

Distribution: White - Office of Construction; Yellow - Transportation Center Materials Office; Pink - Project Engineer Office; Goldenrod - Inspector

Signature _____

Figure 3. Form 830224 Combined Daily Inspection Report of Portland Cement Concrete

Form 830211 3-82

Iowa Department of Transportation
WEEKLY CONCRETE REPORT

Contractor _____ County _____
Week _____ Project No. _____
Report No. _____ Design No. _____ Group No. _____ Contract No. _____ Plant Inspector _____ Cert. No. _____
Monitor Inspector _____

A Item No. and Unit Poured (Design No.)	B Date Poured	C Mix No.	D No. Cu. Yds. Batched	E Dry Batch Weights/Cu. Yd. Fine Agg. Lb.	F Dry Batch Weights/Cu. Yd. Coarse Agg. Lb.	G Moisture (Percent) Fine Agg. Sand	H Moisture (Percent) Coarse Agg.	I Actual High/Low W/C	J Actual Batch Weights/Cu. Yd. Pounds Cement	K Actual Batch Weights/Cu. Yd. Pounds Fly Ash	L Actual Batch Weights/Cu. Yd. Fine Agg. Lb.	M Actual Batch Weights/Cu. Yd. Coarse Agg. Lb.	N Concrete Estimated Plan Quantity (Cu. Yds.)	O Concrete Used (Cu. Yds.)	P Concrete % of Est. Used	Q Concrete treatment*	R Air Content %	S Slump In.

Placement: ☐ Bucket ☐ Belt ☐ Pump

ADDITIONAL SLUMP, AIR TESTS & REMARKS:

BRIDGE DECK CONCRETE TEMP.

Time							
Temp							

			TOTAL CU. YDS. EST.
			TOTAL THIS REPORT
			TOTAL LAST REPORT
			TOTAL TO DATE

Sample I.D.	Grad. No.	AGGR. SIEVE ANALYSIS PERCENT PASSING 1½ in.	1 in.	¾ in.	½ in.	⅜ in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	Complies
Average														

*** CONCRETE TREATMENT**

NOTE: Protected means cold weather protection.

1	Heated water only with no protection	6	Ice added
2	Heated materials with no protection	7	Nitrogen added
3	Protected concrete but did not heat materials	8	Superplasticizer added
4	Heated materials and protected concrete	9	Microsilica added
5	Retarder used in concrete		

	Source/Brand Name	T-203 No./Type/ Class	T-203 Sp. Gr.*	Field Sp. Gr.	Cert. Ton (this week)
F.A.					
C.A.					
Cement					
Fly Ash					

* Put a √ after number if DWU

DATA TO BE REPORTED FOR BEAMS MADE ON REPORT DATE:

Date	Beam No.	% Air	Slump	W/C	Remarks

BRIDGE DECK WEATHER INFO

	Est.	Actual
Rel. Humidity		
Wind Velocity		
Air Temp. *(max.)*		
Air Temp. *(begin)*		

	Brand Name	Rate	Lot. No.
Air Entraining			
Retarder			
Water Reducer			
Superplasticizer			
Microsilica			

DATA TO BE REPORTED FOR BEAMS TESTED ON DATE OF THIS REPORT:

Beam No.	Mix No.	Age Days	Depth Inches	Width Inches	Indicated Load	Actual Load	End Reaction (Pounds)	Computation Factor	Mod. of Rupture	Location of Break

Concrete Source: Name _____
Location _____
Mixing: ☐ Central ☐ Site ☐ Transit

PROJECT INSPECTOR _____

Figure 4. Form 830211 Weekly Concrete Report

and paving history information. Information from both the plant and grade is also entered onto the same forms. This can be inefficient in the field and cause reporting delays. Three to five days are required to transmit the time-critical process-monitoring information to the TCME. Initially plant information is filled in by the CPI. The Plant Monitor reviews this information and then carries the form to the grade inspector so information may be copied from the grade inspector's field book. Next the form is reviewed by the Project Engineer's staff. The form is then mailed to the TCME.

Repeated reviews add to delays. Much of the information may be checked up to four or more times. There were indications that many of these reviews were cursory, possibly because it is assumed that others have or will properly review the form. The research team is recommending fewer, more complete reviews.

Improvement efforts were directed toward concentrating time-critical process-monitoring information on one form that could be faxed to the TCME and Project Engineer. Less time critical information is supplied by copying field book pages and sending them as necessary. See Figure 5 for a diagram of the proposed information flow.

Below is a description of the revised forms categorized by the people responsible for filling them out.

Certified Plant Inspector (CPI)

The CPI is responsible for both the quality control of material produced and recording information in the loose-leaf plant book. The plant book provides the source of all plant-related information required during a project. The pages are retained in the plant book during the project and a complete copy of the plant book will be given to the Project Engineer at the end of the project. Some pages will be copied and sent during the project. These are noted in the descriptions. The pages are developed to facilitate the data collection and to report information on materials used. An illustration of the relationship between the plant book pages is provided (Figure 6).

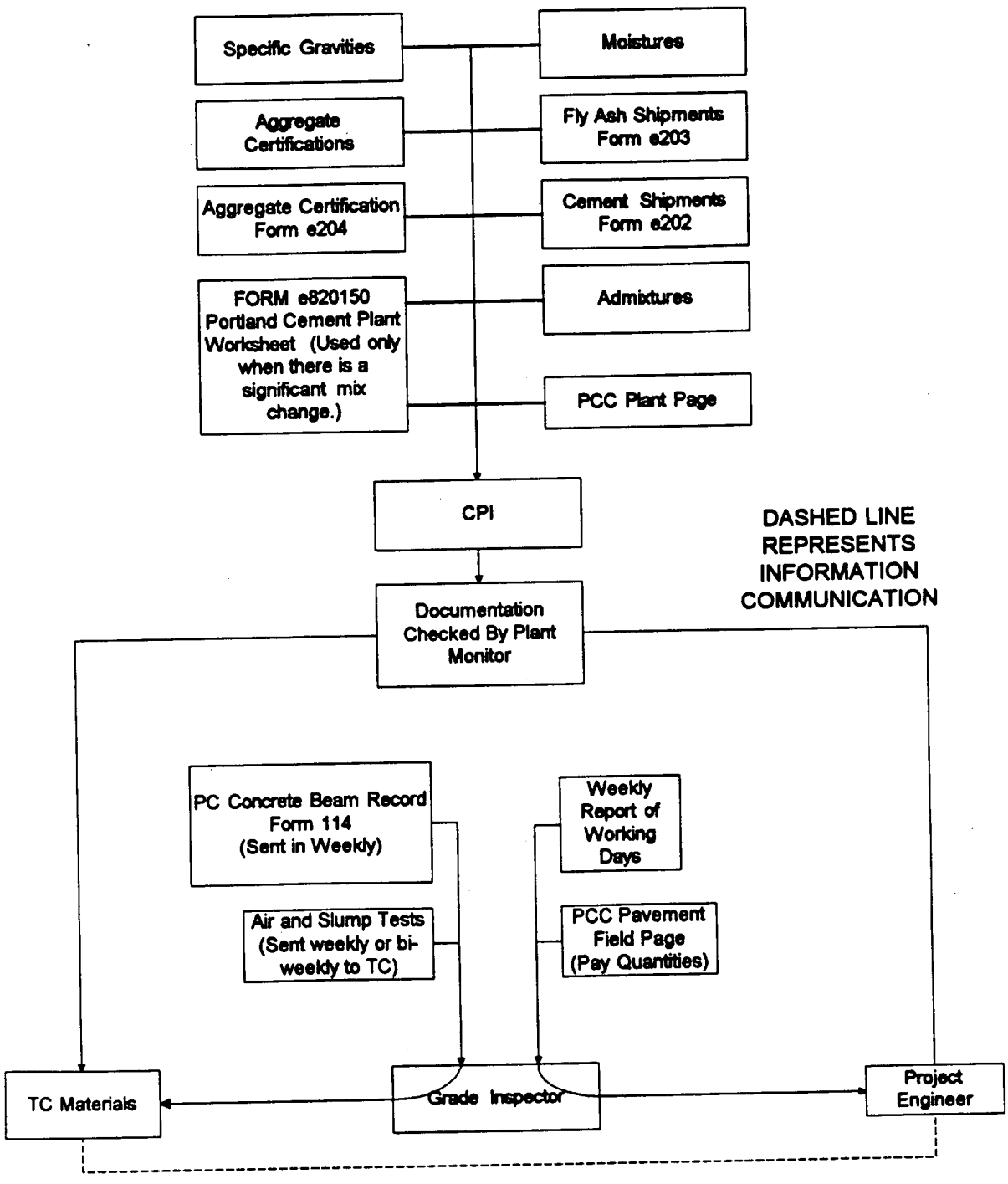

Figure 5. Proposed information flow (PCC)

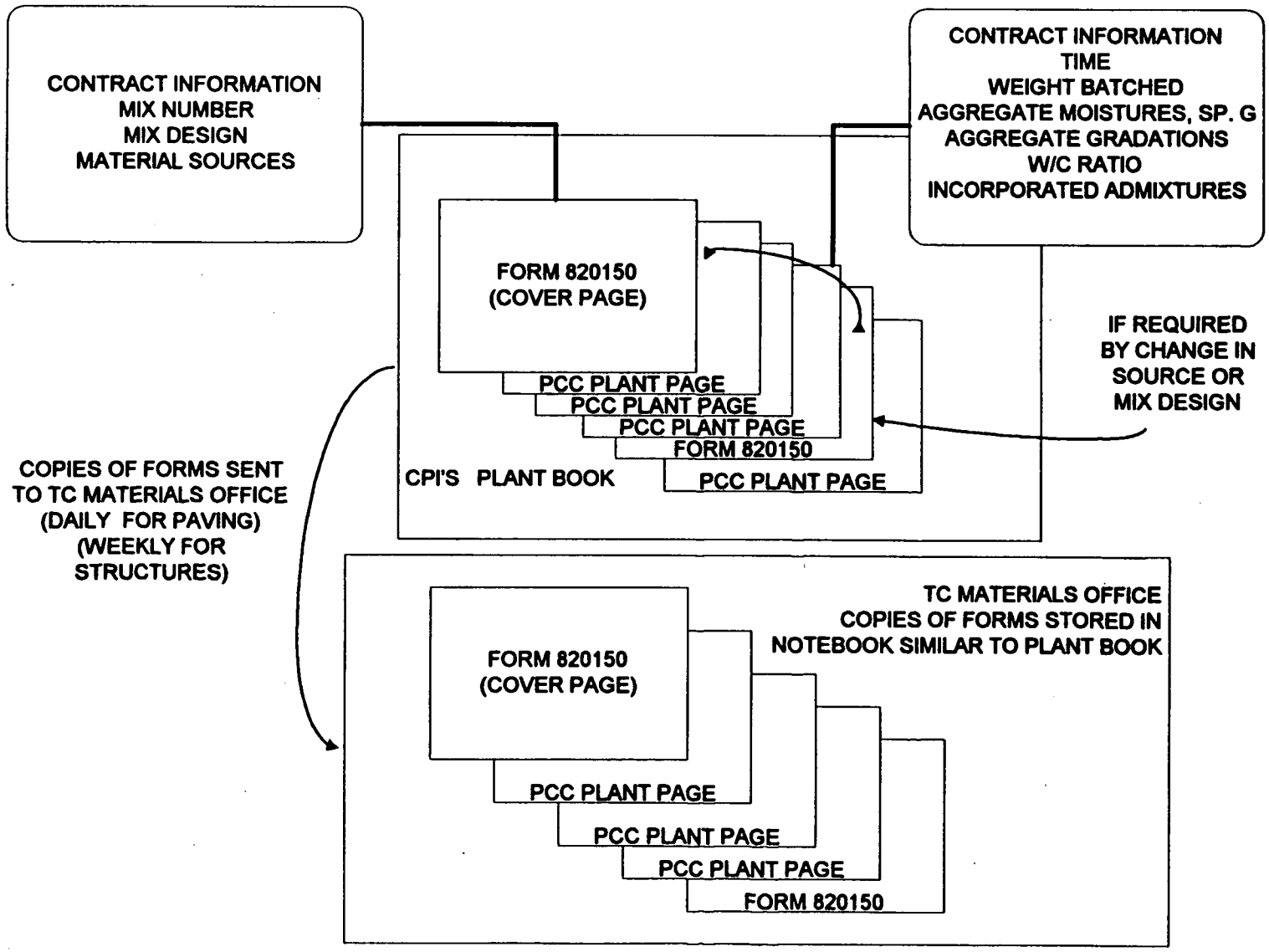

Figure 6. PCC Plant Book Relationships

For process monitoring:

- Form e820150 *Portland Cement Concrete Form* (Figure 7) contains the documentation for material sources and batch weight calculations. This form is completed and a copy is sent to the TCME for each major source change or change in mix design. A copy is distributed to the TCME, Project Engineer, and contractor. This form will contain cement, aggregate, and fly ash source information, which is important for paving histories. It will also serve as the cover page for the *PCC Plant Pages* (explained below) that corresponds to the particular *Portland Cement Concrete Form*. When a new *Portland Cement Concrete Form* is completed, it will serve as a cover page for each future *PCC Plant Book Page* until another cover page is completed. Multiple *Portland Cement Concrete Forms* are uncommon on most PCC projects for a single concrete mix.
- Form E240 *PCC Plant Page* (Figure 8) documents all of the information important for process monitoring that is collected at the plant for all PCC projects. It replaces the plant portion of the Form 830224 *Combined Daily Inspection Report of Portland Cement Concrete* (Figure 3) and Form 830211 *Weekly Concrete Report* (Figure 4). A copy is sent (preferably by fax) to the TCME and the Project Engineer at the end of each day on a paving project and each Friday for structures projects. It contains information such as batch quantities, aggregate moistures, specific gravities, and gradations, the water/cement ratio, admixtures, and weather information.

The *PCC Plant Page* also serves as the gradation worksheet. The worksheet is arranged so that the washed portion of the coarse sample does not need to be carried down to the lower portion of the worksheet as required by Form 820180 *Sieve Analysis Worksheet*. Instead, it is contained within the coarse sample area of the worksheet. If additional gradations are required, another PCC Plant Page can be used and only the gradation worksheet portion used. The CPI will not need to fill out Form 820180 *Sieve Analysis Worksheet*.

The following forms are required for auditing purposes (some information is also gathered from forms listed above):

- The plant book will adopt Form 820912 *Portland Cement Shipment Yield Report* (Figure 9) as a loose-leaf page to document the delivery of cement shipments on paving projects.

Rev 1/95

Iowa Department Of Transportation
Office Of Materials
PORTLAND CEMENT CONCRETE

Form e820150

County No.:_____

Project No.:_____ Acct ID No.:_____ Page No.:_____

Mix No.:_____ Pounds Cement:_____ % Fly Ash:_____

Adjusted Pounds Cement: _____ Source:_____ Sp. Gr.:_____

I.M. 491.17 Fly Ash:_____ Source:_____ Sp. Gr.:_____

IMT-203 Fine Aggregate Source:_____ Sp. Gr.:_____

IMT-203 Coarse Agregate Source:_____ Sp. Gr.:_____

Water (kg/m3) = Design w/c (wt. cement + wt Fly Ash)
(lbs/cy)

Absolute Volumes

Cement ..... (kg/m3) \ (Sp. Gr. X 1000)
(lbs/cy) \ (Sp. Gr. X 62.4 X 27) = _____

Fly Ash ..... (kg/m3) \ (Sp. Gr. X 1000)
(lbs/cy) \ (Sp. Gr. X 62.4 X 27) = _____

Water ..... (kg/m3) \ (Sp. Gr. X 1000)
(lbs/cy) \ (1.00 X 62.4 X 27) = _____

Air 0.060

Subtotal = _____

1.000 - Subtotal = _____

Total = 1.000

% FA Agg.:_____ Fine Aggregate (1.000 - Subtotal) X % In Mix = _____

% CA Agg.:_____ Coarse Aggregate (1.000 - Subtotal) X % In Mix = _____

Aggregate Total = _____

Aggregate Weights

Fine Aggregate (abs vol.) X Sp. Gr. X 1000
(abs vol.) X Sp. Gr. X 62.4 X 27 = _____

Coarse Aggregate (abs vol.) X Sp. Gr. X 1000
(abs vol.) X Sp. Gr. X 62.4 X 27 = _____

Summary

Cement _____ kg/m3 (lbs/cy)
Fly Ash _____ kg/m3 (lbs/cy)
Water _____ kg/m3 (lbs/cy)
Fine Agg. _____ kg/m3 (lbs/cy)
Coarse Agg. _____ kg/m3 (lbs/cy)

Distribution: Materials, TC, Proj. Engr., Contractor

Figure 7. Form e820150 Portland Cement Concrete Form

9/96

PCC Plant Page

Page: _____

Project No.: NHSN-63-9(19)--2R-45 | County: Howard | Report No.: 6

Plant Name: Croell R/M - Elma | Weather: | Date This Report: 07/13/96

Contractor / Sub: Wicks Construction - Sub | Min. Temp. (°C): | Date Of Last Report: 07/06/96

Contract ID.: 45-0639-019 | Max. Temp. (°C): | Design No.: 748

Check One (x)		Check One (x)		
Central Mix		Paving	x	(Send Daily or End of Lot)
Ready Mix	x	Structure	x	(Send Weekly or End of Lot)
Mobile Mix				(Send Weekly or End of Lot)

Year 1996 Date	Mix Number	Time Start	Time Stop	Batched (m3)	% of Est. Used	Fine Aggregate Moist. (%)	Fine Aggregate T-203 Sp. G.	Fine Aggregate Dry Wt. (kg)	Coarse Aggregate Moist. (%)	Coarse Aggregate T-203 Sp. G.	Coarse Aggregate Dry Wt. (kg)	Actual Quantities Used Per m3 (in kilograms) Cement	Fly Ash	Fine	Coarse	Water In Agg.	Water Plant	Water Grade	Avg. W/C Ratio	Max. W/C Ratio
07/09	D-57			5.73	101.1	3.6	2.65	832.0	0.4	2.54	798.0	421.0		863.0	801.0	34.0	149.0	1.0	0.437	0.450
07/10	M-4			1.91	100.0	3.6	2.65	827.0	0.4	2.54	790.0	490.0		858.0	793.0	34.0	147.0	1.0	0.371	
07/12	C-4			50.84	100.7	3.6	2.65	877.0	0.7	2.54	843.0	371.0		910.0	849.0	39.0	131.0		0.458	0.488

COARSE AGGREGATE

Sieve Accuracy= 100.0%

Sieve Size	Orig. Dry Weight (OD Wt.): 6808.7 / Dry Wt. Washed (D Wt. W): Wt. Retd.	% Retd.	% Retd.	% Psg.
37.5mm				100.0
26.5mm	26.1	0.4		99.6
19mm	1656.2	24.3		75.3
13.2mm	2463.0	36.2		39.1
9.5mm	1637.4	24.0		15.1
4.75mm	999.8	14.7		0.4
2.36mm	22.4	0.3		0.1
Pan	5.0	0.1		
Total	6809.9	100.0		
75um				0.6
Wash Loss	18.9	OD Wt.: 3294.4		
Pan	2.4	D Wt. W.: 3275.5		
Total	21.3			

Sieve Accuracy=

Sieve Size	Orig. Dry Weight (OD Wt.): / Dry Wt. Washed (D Wt. W): Wt. Retd.	% Retd.	% Retd.	% Psg.
		OD Wt.:		
		D Wt. W.:		

Sieve Accuracy=

Sieve Size	Orig. Dry Weight (OD Wt.): / Dry Wt. Washed (D Wt. W): Wt. Retd.	% Retd.	% Retd.	% Psg.
		OD Wt.:		
		D Wt. W.:		

Specs.	Avg.
100	
95-100	
25-60	
0-10	
0-5	
0-1.5	

Check One (x):	Today	Week x	Total
Concrete Batched(m3)		58.48	732.63
Cement Batched(Mg)		22.21	343.56

	Brand / Source	Rate	Lot No.
Air Entrain:	DV 1000 - WR Grace		CF03 A183-8
Wat. Red:			
Retarder:			
Cal. Chlor:			
Superplas:			

Concrete Treatment (x)	kg / m3
Ice	
Heated Water	
Heated Materials	

FINE AGGREGATE

Sieve Accuracy= 100.0%

Sieve Size	Wt. Retd.	% Retained	Final	% Passing
	Orig. Dry Weight: 637.8 / Dry Wt. Washed: 633.9 / Washing Loss: 3.9			
9.5mm				100.0
4.75mm	29.1	4.6		95.4
2.36mm	55.1	8.6		86.8
1.18mm	85.1	13.3		73.5
600um	144.6	22.7		50.8
300um	225.2	35.4		15.4
150um	87.8	13.8		1.6
75um	6.0	0.9		0.7
Wash	3.9	0.7		
Pan	0.8			
Total	637.6	100.0		
Date Reported (DR):	07/09/96			
Tested By/Date (TB/D):	Doug Kronneman		NE-386	

Sieve Accuracy=

Sieve Size	Wt. Retd.	% Retained	Final	% Passing
	Orig. Dry Weight: / Dry Wt. Washed: / Washing Loss:			
(DR):				
(TB/D):				

Sieve Accuracy=

Sieve Size	Wt. Retd.	% Retained	Final	% Passing
	Orig. Dry Weight: / Dry Wt. Washed: / Washing Loss:			
(DR):				
(TB/D):				

Specs.	Avg.
100	
90-100	
70-100	
10-60	
0-1.5	

Mobile Mixer	
Cement Meter	Water Meter

Remarks
C-4 mix was used for bridge approaches.
D-57 mix was used for barrier rails.

C.P.I.: Doug Kronneman — Cert. No. 795

Monitor: Danny Steenhard — NE-386

Figure 8. Form E240 PCC Plant Page

Form 820912M
5-95

Iowa Department of Transportation
Office of Materials

Page _____ of _____

Report No. _____

Date _____

PORTLAND CEMENT SHIPMENT YIELD REPORT

County _____ Source _____ Contract No. _____

Project _____ Contractor _____

Plant Location _____

	Date	Type	Invoice No.	Mass Billed *(Mg)*		Date	Type	Invoice No.	Mass Billed *(Mg)*		Date	Type	Invoice No.	Mass Billed *(Mg)*
1					21					41				
2					22					42				
3					23					43				
4					24					44				
5					25					45				
6					26					46				
7					27					47				
8					28					48				
9					29					49				
10					30					50				
11					31					51				
12					32					52				
13					33					53				
14					34					54				
15					35					55				
16					36					56				
17					37					57				
18					38					58				
19					39					59				
20					40					60				

Mix No.	kg Cement per m^3	m^3 Batched	Cement Batched *(Mg)*
Left in Scale *(Mg)*	This Check (+)		+
	Previous Yield Check (-)		-
	Total Weighed *(Batch Scale)*		

Total Billed Mass *(Mg)*:

$$\text{Yield Percent} = \frac{\text{Total Mg Batched}}{\text{Total Mg Billed}} \times 100$$

$$\frac{(\quad\quad)}{(\quad\quad)} \times 100 = \_\_\_\_\_ \%$$

Plant Inspector

Distribution: White Copy-Materials Office; Yellow Copy-Transportation Center Materials Office; Pink Copy-Project Engineer; Goldenrod-Inspector

Figure 9. Form 820912 Portland Cement Shipment Yield Report

The amount of cement weighed by the supplier is verified to match the amount weighed and used at the plant. The shipment information will be recorded during each delivery, and the yield will be calculated at intervals of approximately 10,000 cubic yards after the original determination made near the end of the first full day of production. A new page will be used at each interval and a copy will be sent to the TCME once the report is completed.

On structures projects, the cement shipment yield is not calculated. The same form will be used to record the cement shipments. The form will indicate that calculations should be made for paving projects only.

Paving histories are constructed by collecting information from many of the forms listed above. Important portions collected from the information reported by the CPI include: mix types and proportions, cement brand and type, fly ash source and type, fine and course aggregate source, air entraining brand, retarder brand, and water reducer brand.

Plant Monitor

The Plant Monitor is also responsible for auditing the Form E240 *PCC Plant Page* (Figure 8) daily or weekly on paving or structures projects before a copy is sent to the TCME. No changes were made in the documentation required by the Plant Monitor.

Grade Inspector

During a PCC paving or structures project, the grade inspector is responsible for inspecting the construction operations at the point of placement and completing the loose-leaf field book for the project. The loose-leaf pages designated for a PCC paving operation are.

- Form E023 *PCC Pavement Field Page* (Figure 10), is used on paving projects for pay quantity determination and contains information for process control and paving histories. This form is retained in the grade inspector's field book page and can be accessed by the RCE or Project Engineer. The grade inspector will use this form to complete the progress pay voucher. The results from the percent (%) of estimated used column will be called in to the TCME at the end of each day's paving. That percent is the percentage of the planned quantity that is actually used. It is calculated by dividing the amount of

1/99 Form E023

Item Code: _____ Page No.: _____

Description: _____ Category No.: _____

Project No.: _____ Acct ID No.: _____

Date	Station		Lane	Mix No.	Time		Length (ft)	Width (ft)	Estimated CY Today	Used (CY)		Est. Used (%)	Slip or Fixed (S/F)	Cold Wethr (Y/N)	Pay Today (SY)	Pay To Date (SY)	By
	From	To			Start	Stop				Today	To Date						

Qty. Awarded: _____ Method of Measurement: _____

CO Adjust.: _____ Basis of Payment: _____

Authorized: _____ Checked By: _____

Quantity Paid: _____ Audited By: _____

% Authorized: _____

Figure 10. Form E023 PCC Pavement Field Page

- PCC used by the planned quantity (estimated) and multiplied by 100. A substantial deviation from 100% indicates a possible problem that may be caused by the plant, the grade, or both. Plant-related problems include malfunctioning scales and equipment or calculation errors by the CPI. Grade-related problems may be improper pavement thickness or improper formwork on structures. Although a change in yield does not directly indicate the problem, it may alert personnel to problems that would otherwise go unnoticed.

  After the completion of each paving item, a copy of the loose-leaf page(s) will be sent to the TCME for continuation of the auditing process.

- Form E043 *PCC Structures Field Page* (Figure 11) is used on structures projects for pay quantity determination and contains information for process control and other administrative purposes. This form is retained in the grade inspector's field book page and can be accessed by the Project Engineer. The grade inspector will use this form to complete the progress pay voucher. The percent (%) of estimated used does not need to be reported as with PCC paving projects.

- Form 114 *PC Concrete Beam Record* (Figure 12) contains the information for each beam that is made and broken during the project. The CPI performs beam breaks on paving projects and will have this form instead of the grade inspector. As discussed earlier, this information is critical in the field for decision making regarding stripping forms, backfilling, and opening new PCC to traffic (construction and public). This record will be used by the RCE, grade inspectors, and contractor regarding these activities. An updated copy will be sent each Friday to the TCME for review to assist in material monitoring.

  In the proposed system, this form will contain information for both making and breaking the beam. Currently, the make and break information for the same beam is recorded on two different reports. The proposed system greatly improves the ease of reviewing the completed beam information.

- Form 115 *Air and Slump Test* (Figure 13) contains the air and slump measurements for each test taken during the project. This form has been revised from the current form and contains additional information such as location, application, and remarks area. The location information is important on paving projects for linking the test to the particular

Rev 12/95 Form E043

Item Code: _____ Page No.: _____

Description: _____ Category No.: _____

Project No.: _____ Acct ID No.: _____

Date	Design No.	Mix No.	Unit Poured	Plant Name	Plan Today (CY)	Actual Used (CY)	Est. Used (%)	Cold Wethr (Y/N)	Plan To Date (CY)	By

Qty. Awarded: _____ Method of Measurement: _____

CO Adjust.: _____ Basis of Payment: _____

Authorized: _____ Checked By: _____

Quantity Paid: _____ Audited By: _____

% Authorized: _____

Figure 11. Form E043 PCC Structures Field Page

Rev 12/95 Form E114

PC Concrete Beam Record

Item Code: _____ Page No.: _____

Description: _____ Category No.: _____

Project No.: _____ Acct ID No.: _____

Beams Made Information							Beam Break Information								
Made	Mix Number	Beam No.	Time	Air %	Slump (in)	W/C Ratio	Age (Days)	Depth (in)	Width (in)	Indicated Load	Actual Load	Comp. Factor	Mod. Of Rupture	Loc. (in)	By

Checked By: _____

Figure 12. Form 114 PC Concrete Beam Record

Rev 12/95 Form E115

Air and Slump Tests

Page No.: _____

Contractor: _____ Category No.: _____

Project No.: _____ Acct ID No.: _____

Date	Location	Mix Type	Air (%)	Slump (in)	Application	Remarks	By

Figure 13. Form 115 Air and Slump Test

location of the project and can be important for paving histories. The application entry on the form refers to the Concrete Specifications Summary card that is provided by the Iowa DOT. This entry assists the inspector in determining the proper air and slump specifications that vary with the concrete application.

A copy of this form will be sent to the TCME each Friday.

ACC Paving

The design of asphalt concrete mixes involves selecting an economical blend of aggregates that provides a combined gradation within the limits of the specifications and a determination of the percent asphalt to mix with the aggregate blend. Trial mixes prepared with different asphalt contents are tested for mix properties and the results analyzed to select the asphalt content that is judged to be most satisfactory.

As an overview, the characteristics of ACC are determined by the quality and proportion of raw materials (aggregate and asphalt cement) mixed together to produce the ACC. Important characteristics of ACC aggregates are cleanliness, toughness, surface texture, particle shape absorption, affinity for asphalt, and size and gradation (Asphalt Institute 1989, p. 85). The Iowa DOT supplies a list of approved sources for both asphalt cement and aggregates and specifies acceptable gradations.

A typical ACC paving project is supplied by an asphalt plant that can function as a batch plant, drum mixer, or continuous plant. The plant can either be a stationary commercial plant or a mobile plant. Dump trucks deliver the hot asphalt to the paver at the grade. An asphalt truck ticket is required for each truckload of asphalt. The ticket contains information such as truck number, the mix type, the weight of the truck, the running total of asphalt for the day, the date, the time, the job, and the location. There are four carbon copies. One is kept by the truck driver who needs a copy for weight information if he is stopped by a weight inspector. Another copy is given to the trucker for delivery to the grade inspector. Another copy is sent to the plant monitor and the last ticket is retained by the contractor. The tickets are collected by the grade inspector to assure that the each load that is paid for is actually placed at the site.

The proportioning of ACC materials determine the quality of the end product. Gradation, film thickness, stability, asphalt content, and voids are considered when establishing the initial mix design and when making changes. The laboratory voids and density are of primary importance in the quality control of an asphalt concrete mixture.

As with PCC paving, daily monitoring is required to assure that materials of specified quality are used in the correct proportions and placed in a manner to provide a quality product. To promote this, the Iowa DOT and some local jurisdictions have implemented the Quality Management Asphalt (QMA) program. This program allows the contractor to control the mix design and be responsible for the Job Mix Formula (JMF), which is reviewed by the Iowa DOT, and for the quality of the placed product. The JMF is reviewed by the TCME. Changes in JMF must be agreed to by the TCME and is documented by Form 370-*830908 Report of Field Changes in Asphaltic Concrete Mix Proportions.*

The QMA program facilitates the exchange of information between the plant and the TCME. A report faxed directly to the TCME for each day of production was developed. Many other improvements were also made in the documentation with the development of loose-leaf plant and field book pages.

The field data collection and reporting system for ACC paving was analyzed in the same manner as described earlier for PCC projects. Because of the recent improvements made in this area, fewer improvements are recommended. One of the main problems discovered with the current system was the use of multiple forms which contained portions of similar information:

- Form 820007 *Daily Plant Report* (Figure 14)
- Form e236 *QMA Test Summary Sheet* (Figure 15)
- Form e216 *ACC Mix and AC Record* (Figure 16)
- The two upper portions (which were filled out in the field) of Form 821017 *QMA Sampling Log and Core Calculations Report* (Figure 17).

For example, the tank stick % asphalt content is repeatedly documented on Form 820007, Form e236, and Form e216.

After analyzing these forms and suggested replacement forms, Form e241*Daily ACC Plant Page* (Figure 18) was developed, which contains all of the information

Form 820007 08/90 H-1661

Iowa Department of Transportation

DAILY PLANT REPORT

BITUMINOUS TREATED BASE, ASPHALT TREATED BASE, ASPHALT CONCRETE

County _____
Project _____
Contract No. _____
Date _____
Report No. _____

Contractor _____ Plant Location _____

Plant Type _____ Make _____ Pollution Equipment _____ Resident Engineer _____

Mix Type _____ Class _____ Size _____ Crushed Aggr. Sources _____ Recycle Source _____

Asphalt Source & Grade _____ Sand Sources _____ Plant Operated _____ A.M. to _____ P.M. Mix No. _____

SIEVE ANALYSIS OF COMBINED AGGREGATES

SAMPLE			SIEVE NO. - % PASSING											
JOB MIX FORMULA - LIMITS														
Spl. ID	Time	Compl.	1½	1	¾	½	⅜	4	8	16	30	50	100	200

SAMPLES SUBMITTED		SAMPLES SUBMITTED	
Materials	Senders No.	Materials	Senders No.

Intended Added _____ % A.C. Tank Meas. _____ % A.C.
Intended Total _____ % A.C. Total _____ % A.C.

LAB. DEN. / DENSITY RECORD / SOLID DEN.

Course Laid	Station	¢ Refer	Date Laid	* (1)	Density	% Density	% Voids

TEMPERATURE RECORD

Time	7	9	11	1	3	5
Air						
A.C.						
Aggr.						
Mix						
Mat						

RECYCLED MIX ONLY

Total RAP Used Tons _____
Total Aggr. Used Tons _____
RAP Used % _____
Aggr. Used % _____

MATERIALS DELIVERIES

Type	Ticket No.	Quantity

Avg. Field Density Lot #1 _____
Avg. Field Density Lot #2 _____

Advisory - Fines/Bitumen Ratio =
Ave. % Field Voids =
Lab % Voids =
Q.I. (Density) =
(Show Calculation)

PRODUCTION AND PLACEMENT RECORD

* (2)	Side	Course Laid	From Station to Station	Tons Today	Tons To Date

Acceptance Cold Feed (Certified Projects Only)	1	¾	½	⅜	4	8	16	30	50	100	200

COMMENTS

Acceptance Fines/Bitumen Ratio = _____

COMMENTS: Delays, Breakdowns, Corrective Action, etc.

Signed _____
Inspector

Figure 14. Form 820007 Daily Plant Report

Rev 1/95 Form e236

QMA TEST SUMMARY SHEET

Project No.:_____ Contractor:_____

Acct ID No.:_____ Mix Design No.:_____

County:_____ Mix Type:_____

TEST #								
DAY #								
DATE								
1" Sieve								
3/4" Sieve								
1/2" Sieve								
3/8" Sieve								
* #4 Sieve								
Moving Average								
* #8 Sieve								
Moving Average								
#16 Sieve								
* #30 Sieve								
Moving Average								
#50 Sieve								
#100 Sieve								
* #200 Sieve								
Moving Average								
% AC TANK								
Max. Mix Gravity								
Marshall Gravity								
Marshall Voids								
Moving Avg. (n=4)								
Tons Represented								
Cumulative Tons								
Avg. Daily Core Sp. GR. (n=7)								
Avg. Marshall Gravity								
Field % Marshall								
Avg. Max. Mix Gravity								
Field % Voids								
QUALITY CONTROL ACTIONS: 1.) AC Changes 2.) Cold Feed Adjust. 3.) Moisture Adjust. 4.) Etc.								

* Sieve Results To Be Plotted

- All Moving Averages Based On 4 Test Values

Figure 15. Form e236 QMA Test Summary Sheet

Rev 5/85 Form e216

ACC Mix & AC Record

Page No.: _____

Project No.: _____ Acct ID No.: _____

Date	Made (Tons)	Plant Waste (Tons)	Road Waste (Tons)	Total Waste (Tons)	Mix Used (Tons)	To Date (Tons)	Tankstick (%)	AC Used (Tons)	To Date (Tons)	Remarks	By

Checked By: _____

Audited By: _____

Figure 16. Form e216 ACC Mix and AC Record

Form 821017
11-94

QMA SAMPLING LOG AND CORE CALCULATIONS REPORT

Date _____

Report # _____

Project No. _____ Contractor _____

County _____ Mix Type _____

Contract No. _____ Mix Design # _____

HOT SAMPLE LOG

Sample Id.						
Test No.						
Date Sampled						
Time						
Side/Lane						
Station						
Course Laid						
Sample Ton						
Sampled By						

Avg. Daily Lab S.G. _____ Avg. Daily Max. S.G. _____ Fines/Bitumen =

CORE CALCULATIONS

Date Placed: _____ Date Tested: _____ Tested By: _____

Core No.	STA	℄ Ref.	W1 Dry Mass	W2 Mass In Water	W3 Wet Mass	Difference	Field Density	% Avg. Lab Density	% Air Voids	Core Thickness
1										
2										
3										
4										
5										
6										
7										
						Average				

Quality Index = _____ / _____ =

TRANSPORTATION CENTER LAB TEST RESULTS

Date Tested: _____ Tested By: _____

Core No.	W1 Dry Mass	W2 Mass in Water	W3 Wet Mass	Difference	Field Density	Correlation Difference	% Avg. Lab Density	% Air Voids	Core Thickness
1									
2									
3									
4									
5									
6									
7									

Problems encountered with correlation of field sample, if any: _____

_____

_____
Transportation Center Laboratory

Distribution: **White Copy** - Transportation Center Lab Copy *(copy to Ames, Proj. Eng., Transportation Center Materials)*; **Yellow Copy** - Plant File Copy; **Pink Copy** - Contractor

Figure 17. Form 821017 QMA Sampling Log and Core Calculations Report

9/96

DAILY ACC PLANT PAGE

Form E241

Project No.: _____ Mix Design No.: _____ Mix Type: _____ Page No.: _____

County: _____ Contractor: _____ Class: _____ Report No.: _____

Contract ID.: _____ Recycle Source: _____ Size: _____ Design Marshall Blows: _____

Hot Box I.D. No.:							
Date Sampled:							
Target & Gradation ID:	Target						
1" Sieve							
3/4" Sieve							
1/2" Sieve							
3/8" Sieve							
* #4 Sieve							
Moving Average							
* #8 Sieve							
Moving Average							
#16 Sieve							
* #30 Sieve							
Moving Average							
#50 Sieve							
#100 Sieve							
* #200 Sieve							
Moving Average							
Compliance (Y/ N)							
Intended Added, % AC							
Tank Meas., % AC							
Intended Total, % AC							
Total, % AC							
Marshall Sp. Grav.:							
Max. Sp. Grav.:							
Marshall Voids							
* Moving Avg. (N=4)							
Time							
Station							
Side							
Sample Ton							
Sublot Tons							
Tons to Date							
Fines / Bitumen Ratio							
QUALITY CONTROL ACTIONS: 1.) AC Changes 2.) Cold Feed Adjust. 3.) Moisture Adjust. 4.) Etc.							

Time	7:00	9:00	11:00	1:00	3:00	5:00	7:00
Air Temp. (°F)							
A.C. Temp. (°F)							
Mix Temp. (°F)							

Date Placed: _____ Date Tested: _____

Course Placed: _____ Tested By: _____

Density Record

Core No.:	1	2	3	4	5	6	7
Station							
CL Reference							
W 1 Dry							
W 2 in H20							
W 3 Wet							
Difference							
Field Density							
% Density							
% Voids							
Thickness							

Avg. % Field Voids: _____ Avg. Field Density: _____

Marshall Sp. G (Lot Avg.): _____ Avg. % Density: _____

Max. Sp. G (Lot Avg.): _____ Specified Density %: _____

Q.I. = _____ – _____ = _____

Low Outlier: _____ High Outlier: _____ New Q.I. = _____

Film Thickness (FT): _____ VMA: _____

Remarks: _____

C.P.I.: _____ _____ Cert. No.

QMA Tech: _____ _____ Cert. No.

Figure 18. Form e241 Daily ACC Plant Page

supplied by the forms listed above. It should be adopted as a loose-leaf plant book page. A computerized version may also be developed. Only one column of Form e241 is filled out for non-QMA projects. The other columns are for additional information needed for QMA projects. It will be distributed in the same matter as the current Form 820007 and will be faxed to the TCME and the Project Engineer the day following placement. See Figure 19 for an illustration of the information flow.

The lower portion of Form 821017 *QMA Sampling Log and Core Calculation Report*, which is filled out for correlation by the TCME's staff, will be replaced by the form shown in Figure 20, *Transportation Center Materials Lab ACC Core Correlation Results*. The form shown in Figure 20 will also replace Form 510069 *Laboratory Correlation Results* (Figure 21), which is currently used for non-QMA projects. This form number has not yet been reassigned, but is likely to remain Form 821017.

The names of the entries on the current ACC forms are inconsistent. In many cases, different names on the various forms actually refer to the same item. For example, Average % Density (current Form 820007 *Daily Plant Report*) is the same as Field % Marshall (*QMA Test Summary Sheet*). This causes confusion among inspectors and reviewers of the information. Inconsistent item names are a roadblock to implementing database computer systems such as SiteManager. Such systems will only be able to recognize one name for each item. The Iowa State research team analyzed each item of information and with the assistance of the Office of Materials, defined one consistent name for each item.

An additional observation is that extracted gradations are no longer conducted. Therefore Form 820300 *Comparison of Cold Feed and Extracted Gradation Worksheet* should be eliminated.

Proposed ACC System

Form 956 *Asphalt Concrete Mix Design* (Figure 22) will serve as a cover page in the plant and TC Materials project files. Any major changes in the mix such as change in aggregate source will require that the Transportation Center Materials Engineer issue a new Form 956. Material sources and mix design will be referenced from this form.

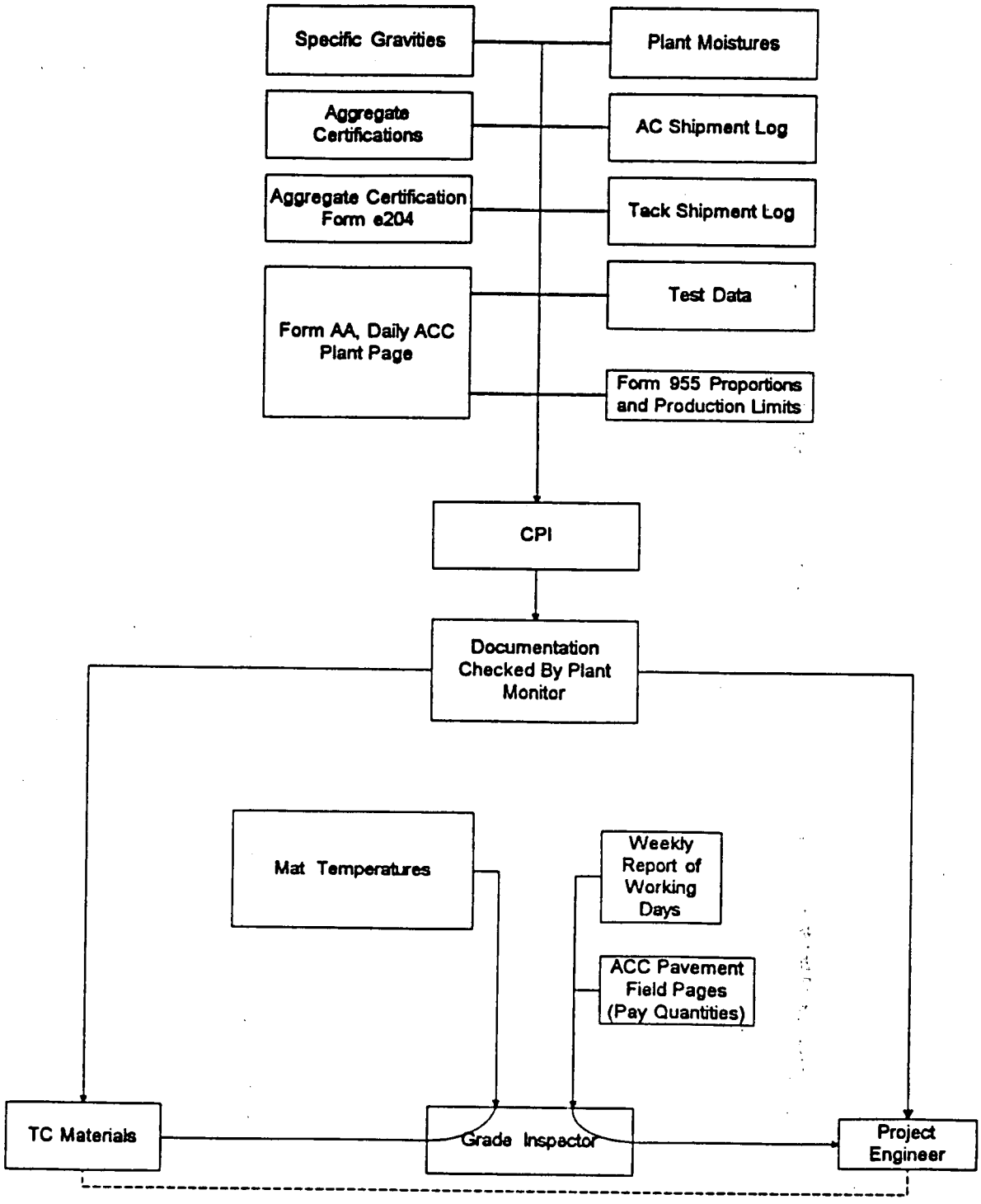

Figure 19. Proposed information flow (ACC)

Form ?

Transportation Center Materials Lab ACC Core Correlation Report

Project No.: _____ Contractor: _____

Contract ID: _____ Mix Type: _____

County: _____ Mix Design No.: _____

Date Placed: _____ Date Tested: _____ Plant Report No.: _____

Core No.	W1 Dry	W2 Water	W3 Wet	Diff.	TC Lab Field Density	Road Field Density	Correlation Difference	Core Thickness
1								
2								
3								
4								
5								
6								
7								

Remarks: _____

Date Placed: _____ Date Tested: _____ Plant Report No.: _____

Core No.	W1 Dry	W2 Water	W3 Wet	Diff.	TC Lab Field Density	Road Field Density	Correlation Difference	Core Thickness
1								
2								
3								
4								
5								
6								
7								

Remarks: _____

Date Placed: _____ Date Tested: _____ Plant Report No.: _____

Core No.	W1 Dry	W2 Water	W3 Wet	W3 - W2 Diff.	TC Lab Field Density	Road Field Density	Correlation Difference	Core Thickness
1								
2								
3								
4								
5								
6								
7								

Remarks: _____

_____
Transportation Center Laboratory

Distribution: ___ Ames ___ Proj. Eng. ___ TC Mat. ___ Contractor

Figure 20. Transportation Center Materials Lab ACC Core Correlation Results

Form 510069
11-94

LABORATORY DENSITY CORRELATION RESULTS
TRANSPORTATION CENTER LAB _____

Date _____
Report # _____

Project _____ County _____

Contract No. _____ Contractor _____

Work Type _____ Field Technician _____

Date Laid _____ Lab. Density _____

Remarks _____ Lab. Sp. G. _____

Submitted Field Test Results

Core No.	1	2	3	4	5	6	7	
Station								
℄ Ref.								
W-1 Air								
W-2 Water								
W-3 Air								
Difference								Avg.
Density								
% Lab Density								
Voids								
Thickness								

Quality Index = _____ − _____ =

Transportation Center Lab Test Results

Core No.	1	2	3	4	5	6	7
W-1 Air							
W-2 Water							
W-3 Air							
Difference							
Density							
% Lab Density							
Voids							
Thickness							
Correlation Difference							

Problems encountered with correlation of field sample, if any: _____

_____

_____
Transportation Center Laboratory

Distribution: White Copy - Transportation Center Lab Copy *(copy to Ames, Proj. Eng., Transportation Center Materials)*; Yellow Copy - Plant File Copy; Pink Copy - Contractor

Figure 21. Form 510069 Laboratory Correlation Results

Form 820956
5-93

Iowa Department of Transportation
HIGHWAY DIVISION
(Office of Materials)

ASPHALT CONCRETE MIX DESIGN - AMES LABORATORY

Mix, Type and Class: _____ Size _____ Contr. No. _____ Lab. No. _____

Intended Use: _____ Spec. No. _____ Date Reported _____

County: _____ Proj. No. _____ Contractor _____

Proj. Location: _____

Agg. Sources: _____

_____

Job Mix Formula Aggregate Proportions: _____

JOB MIX FORMULA - COMBINED GRADATION

37.5mm (1½)	26.5mm (1.06)	19mm (¾)	13.2mm (0.530)	9.5mm (⅜)	4.75mm (4)	2.36mm (8)	1.18mm (16)	600µm (30)	300µm (50)	150µm (100)	75µm (200)
Tolerance											

Asphalt Source and Approximate Viscosity	
% Asph. In Mix	
Number of Marshall blows	
Marshall Stability - Lbs.	
Flow - 0.01 In.	
Sp. Gr. By Displacement (Lab Dens.)	
Bulk Sp. Gr. Comb. Dry Agg.	
Sp. Gr. Asph. @ 77 F.	
Calc. Solid Sp. Gr.	
% Voids - Calc.	
Rice Sp. Gr.	
% Voids - Rice	
% Water Absorption - Aggregate	
% Voids in the Mineral Aggregate	
% V.M.A. Filled with Asphalt	
Calculated Asph. Film Thickness (Microns)	
Filler/bitumen ratio	
Minimum AC Content	
Target Air Voids	

Copies:

Disposition:

SIGNED: _____
(TESTING ENGINEER)

Figure 22. Form 956 Asphalt Concrete Mix Design

Materials deliveries will be handled similarly to the proposed PCC documentation. The plant book will contain pages for coarse and fine aggregates and asphalt shipments. This information will be retained in the field book until needed for auditing purposes.

The sample submitted information was not transferred from the Form 820007 *Daily Plant Report* to the proposed Form e241, *Daily ACC Plant Page* (Figure 18). Form 820193 *Identification of sample* is filled out for each sample and sent to the TC Materials Office. A copy of this form can be retained by the CPI to serve as documentation for samples submitted.

Form e234 *QMA Marshall Test Data* was modified to accommodate four calculations rather than just one. This would eliminate the potential of filling out four separate forms in a given day (Figure 23).

Each inspector's duties will remain the same. The other ACC related forms which have not been mentioned will remain the same and are included in the proposed system. No changes were made in the data collection and reporting responsibilities of the field inspector and plant monitor.

Rev 12/95 Form E234

QMA MARSHALL TEST DATA

Project No.: _____ Mix Design No.: _____ Contractor: _____ Report No.: _____

County: _____ Class: _____ Size: _____ Date: _____

Contract ID.: _____ Mix Type: _____ Recycle Source: _____

Marshall S.G. (Lab Density) Determination

		Marshall Blows Compacted Temp. ° F		Marshall Blows Compacted Temp. ° F		Marshall Blows Compacted Temp. ° F		Marshall Blows Compacted Temp. ° F	
Specimen ID No.:									
Weight In Air (A):									
Weight In Water (C):									
Weight SSD (B):									
Specific Gravity:									
Avg. S.G. (D):									

Mix Maximum (Rice) Specific Gravity Flask Method

Pycnometer No.:	(E)		(E)		(E)		(E)	
Weight; Container & Sample:	(F)		(F)		(F)		(F)	
Weight; Container:	(G)		(G)		(G)		(G)	
"W", Sample Weght ((F) - (G)):	(H)		(H)		(H)		(H)	
"W1", Wt. Pyc. & H2O ** @ Test Temp.:	(I)		(I)		(I)		(I)	
Total Weight ((H) + (I)):	(J)		(J)		(J)		(J)	
"W2", Wt. Pyc. & Water & Sample:	(K)		(K)		(K)		(K)	
Weight Displaced Water ((J) - (K))	(L)		(L)		(L)		(L)	
Test Temperature Of Water ° F:	(M)		(M)		(M)		(M)	
R Multiplier (chart):	(N)		(N)		(N)		(N)	
Maximum S.G. (((H) * (N)) / (L)):	(O)		(O)		(O)		(O)	

** Pycnometer Calibration Sheet

% Air Voids (((O)-(D))/(O))*100) = _____ % Air Voids: _____ % Air Voids: _____ % Air Voids: _____

Notes or Comments: _____

Figure 23. Form e234 QMA Marshall Test Data

IMPLEMENTATION

The revised PCC and ACC systems were implemented in a two stage process. The first stage consisted pilot testing during the 1996 construction season. The second stage is formal, state-wide implementation, which is planned for the 1997 construction season.

Pilot Test

The pilot test program was started on a small scale to identify problems with the new system and allow time for remedies before full implementation. The PCC and ACC systems were implemented in different ways.

For PCC system implementation, each transportation center selected two project for pilot testing. The results of the pilot tests were reported during monthly meetings of the review committee. In July of 1996 surveys were sent out to participants asking what they liked and disliked about the new system. The survey also asked participants to list possible improvements. Respondents generally liked having fewer entries to fill out and having information delivered to the TCME sooner. Concerns were expressed about the readability of the forms after they were sent by FAX. Because of a misunderstanding, one residency was filling out both the new and old forms. Respondents indicated their displeasure over that situation.

For the ACC system, it was deemed necessary to develop a computerized system. This was because a computer program was available under the old system to produce form 820007 and it was considered unacceptable to convert from a computerized system to a manual system. Dan Steenhard of the New Hampton Residency developed a Lotus® -based computer spreadsheet that was based on the new system and exceeded the functionality of the old computer program. Contractors on QMA projects had the option of using either the new or old system during the 1996 construction season. Approximately 50% of the 1996 QMA projects used the new system. The new computer program required 486 computer equipment. Some contractors did not have such equipment and elected to wait to purchase new equipment when full implementation is mandated.

As with the PCC system, progress of pilot implementation was tracked during monthly review committee meetings and through a survey. Respondents indicated that the computer forms took less time to fill out, had fewer errors, were more uniform and easy to read. Respondent indicated concern about computer training issues and indicated a preference for more hands-on training.

Final Implementation

Before final implementation several changes were made, based on feedback from pilot implementation:

- The decision was made develop Lotus ® Spreadsheet program for the PCC forms. This would reduce the amount of hand calculation and increase the legibility of the forms.
- Require fax modems for computers. This would increase the legibility of the forms.
- Send the original forms to the TCME in case the fax copy is hard to read.
- Include a column for a yield check (% of est. used) in form 240 *PCC Plant Page.*
- Develop streamlined input screens in the computer programs that will eliminate the need to hunt for data entry points.
- For ACC projects, use of the computer system is required for QMA projects and optional for non-QMA projects.
- For PCC projects, the use of the computer system is optional, but highly encouraged.

Computer specifications were selected so that contractors could plan computer purchases for the 1997 construction season. Since the Iowa DOT has a large investment in notebook computers for the Electronic Fieldbook, that level of capability was deemed to be an acceptable standard for the foreseeable future:

- 486-33 MHz processor
- 16 MB of RAM
- 14.4 fax modem

- 500 MB Hard Drive
- CD ROM drive
- Bubble jet, ink jet or 24 pin dot matrix printer
- Windows 3.1 (not Windows 95) operating system
- Lotus 5.1 Spreadsheet

Encouragement was given to purchase equipment with greater capability.

Once the ACC and PCC systems were revised to their final design, the final implementation process began. The following IM's were revised to describe the new procedures:

PCC

- I.M. 527 Paving Plant Inspection
- I.M. 528 Structural Concrete Plant Inspection

ACC

- I.M. 508 Instructions For Completing Daily ACC Plant Report
- I.M. 509 Tank Measurement and Asphalt Cement Content Determination
- I.M. 510 QMA Test Equipment

In cooperation with the Iowa Concrete Paving Association, Iowa Ready mixed Concrete Association and the Asphalt Paving Association of Iowa, a training program was developed for the new system:

- Users guides that include tutorials were developed for the new computer programs (Steenhard 1996 a and b).
- The ACC and PCC Technician at each transportation center received special training on the computer programs so they could serve as resource persons and train others.
- The new systems were included in the Iowa DOT Certification, Update and Monitor Administration training classes for 1996 - 1997 winter season.

At this writing, the Iowa DOT intends to fully implement the new PCC and ACC systems during the 1997 construction season.

Benefits

Users of the system have noticed several benefits:

- All forms have fewer entries to make
- All forms provide quicker communication with the TCME office
- All forms require less copying of information from one form to another
- Computer forms provide results to inspectors quickly without having to wait for calculations
- Computer forms are more legible and orderly in appearance
- Computer forms have fewer calculation mistakes and may be reviewed more quickly

It is estimated that the Iowa DOT processes approximately 900 PCC Daily plant reports, 1,400 ACC daily plant reports and 700 PCC (structures) weekly plant reports each year. This is 3000 reports per year in the primary system. Additional reports are generated by local systems users. Informal conversations with Iowa DOT employees indicate that the new system saves approximately two hours for each form. This includes time to fill out, monitor, check, transmit and file the reports. If each staff position represents 2000 hours per year, implementation of the new system will be equivalent to adding three positions to the Office of Construction and Office of Materials with little additional cost. Contractors and local systems users will reap additional saving. These savings are in addition to the ones in the bullet list above that are difficult to quantify.

SUMMARY AND CONCLUSIONS

Recommendations have been made and final implementation has been achieved for a revised field data collection and reporting system for ACC pavements, PCC Pavements and PCC structures. The new system greatly reduces the need for copying information. Separate forms have been established for the field inspectors and plant inspectors so that information is not delayed by the need to pass forms from one inspector to another. Time-critical process-monitoring information has been separated and arranged in a format for electronic transmission to the TCME on the day following production. Forms have been arranged so they can serve as both loose-leaf field book pages and documents to transmit information electronically or by

mail. Uniform terminology has been developed for the identical information in the ACC reporting system. The proposed system is expected to be compatible with the proposed AASHTO SiteManager system.

These improvements will provide a more efficient field data collection and reporting system. Inspectors will more efficiently document information and will be able to spend more time inspecting. The TCME will receive time-critical process-monitoring information much faster than in the current system. This will improve the monitoring process and problems detected by the TCME will be found and corrected sooner. Uniform terminology will decrease the chances of errors caused by the confusion of terms and make training new employees easier.

The revised system was pilot tested during the 1996 construction season. After final revisions were made, the new system was approved for statewide implementation for the 1997 construction season. Training manuals were written and IM's were revised to accommodate the new system. The 1996-97 Technical Training & Certification Program will include information on the new ACC and PCC systems to assist in the implementation.

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Steenhard, Danny. (not dated). *Instructional Guide: Asphalt Cement Concrete Plant Page and Plant Book Computer Programs,* Iowa Department of Tranportation, Ames, Iowa.

Steenhard, Danny. (not dated). *Instructional Guide: Portland Cement Concrete Plant Page and Plant Book Computer Programs,* Iowa Department of Tranportation, Ames, Iowa.

APPENDIX A: REVIEW COMMITTEE MEMBERS

Boulet, Roger H.: ECITC Materials, Cedar Rapids, Ia.

Buchwald, Donna: Field Systems Engineer, Iowa DOT, Ames, Ia.

Dabler G. Roger: Senior Engineering Technician, ECITC, Cedar Rapids, Ia.

De Vries, Steve: Mills County Engineer, Glenwood, Ia.

Elliott, Lance A.: Iowa State University graduate research assistant

Follmann, Russ: Senior Engineering Technician, NWITC, Sioux City, Ia.

A representative from the Office of Local Systems, Ames, Ia.

Halbur, Mike: Iowa State University undergraduate research assistant

Jahren, Charles T., Ph.D.: Iowa State University Assistant Professor

Mathis, Dan: Federal Highway Administration, Ames, Ia.

Osby, Gary: Senior Engineering Technician, SWITC, Atlantic, Ia.

Palmateer, Ivan: Senior Engineering Technician, CITC, Ames, Ia.

Reason, Bob: Senior Engineering Technician, SWITC, Atlantic, Ia.

Smythe, John M.: Iowa DOT Construction Engineer, Ames, Ia.

Thompson, Ron: Senior Engineering Technician, SEITC, Fairfield, Ia.

Veerabhadrappa, Taroon: Iowa State University graduate research assistant

Wiebke, Dean: Senior Engineering Technician, NEITC, Mason City, Ia.

APPENDIX B: LIST OF INTERVIEWS

March 14: Carey Lewis, RCE, Manchester Residency

March 15: Bruce Keel, Roger Dabler, Roger Boulet, ECITC

March 26: Champ Narotam, Materials engineer, CITC

May 26: Les Petersen, inspector, Cherokee residency

June 1: Jim Campbell, Construction Technician, Denison residency

June 2: Jim Haril, inspector, Council Bluffs residency

June 2: Bob Mullin, Construction Technician, Council Bluffs Residency

June 2: Richard Meyer, inspector, Denison residency

June 9: John Lane, Jim Grove, Todd Hansen, Becky Hutchinson, Dave Heer, Central Office, Ames

June 12: Omar Smadi, Iowa Transportation Center, Pavement management

June 13: Quarterly Materials meeting, Waterloo

June 13: Jerry Lund, RCE, Waterloo residency

June 14: Steve Armstrong, inspector, Waterloo residency

June 14: Scott Ernst, CPI, Benton Concrete Ready-Mix, Waterloo

June 14: Rick Lockhardt, CPI, Taracon Consultants

June 15: Bill Kirk, ECITC PCC Technician

June 15: Ray Meyer, inspector, Waterloo residency

June 15: Craig Carradus, CPI, American Testing and Engineering, consultant

June 16: Ron Arends and Randy Lorenzen, City of Cedar Falls Engineers

June 20: Jim Myers and Todd Hansen, Geologist and Historian, Central Office

June 21: David Bergman and Gene Pavelka, inspectors, Britt residency

June 21: Tim Raber, inspector, Britt residency

June 21: Larry Billick, CPI, Cessford Asphalt

June 21: Phil Smithhart, QMA Monitor, Cessford Asphalt

June 22: Ingrid Ruddy, Materials Technician, Frank Neff, PC Technician, Keith Walcon, AC Technician, Fairfield Transportation Center

June 23: Herman Best, CPI, Fredonia Concrete

June 23: Karen Noble, Plant Monitor, Mount Pleasant residency

June 23: Clarence Perry, county engineer, Henry County

June 23: Mike O'Brien, CPI, Carlson

June 23: Larry Delaney, inspector, Mount Pleasant residency

June 24: Joe Demeter and Jim Webb, RCE, Mount Pleasant residency

June 24: Marvin Cruell, AC Technician, Mount Pleasant residency

June 24: Walter Schneider, PC Technician, Mount Pleasant residency

June 29: Dennis Jones and Dick Urecka, inspectors, Red Oak residency

June 29: Larry Cohran, CPI, Cohran Concrete Company

June 30: Steve Devries, county engineer, Mills County

June 30: Jim Haril, inspector, Council Bluffs residency

July 13: John Heggen, Bitumin Engineer, Central Office

July 19: Duane Pullen, inspector, Des Moines residency

July 26: Wayne Sunday, Field Structures Engineer, Central Office

August 9: John Heggen and John Hinrichsen, Central Office

August 10: Clyde Leonard, Materials Engineer, NWITC

August 10: Carl Fenceroy, inspector, Sioux City residency

August 11: Tony Gustafson, RCE, Cherokee residency

August 11: Phil Spencer, AC Technician, Cherokee residency

August 11: CPI from Mathy Construction

APPENDIX C: LIST OF FIELD TRIPS

May 22:	Highway 3 near Remsen
May 22:	US 20 near Correctionville
May 26:	US 34 near Ottumwa
May 30:	T61 in Appanoose county
June 1:	Highway 127 near Logan
June 1:	US 71 near Templeton
June 1:	US 30 near Woodbine
June 2:	Interstate 29 near Council Bluffs
June 14:	New US 218 North of Cedar Falls
June 15:	Interstate 80 near Davenport
June 22:	US 69 near Blairsburg
June 23:	Fredonia Concrete Plant
June 23:	US 218 south of Iowa City
June 23:	Benton Concrete, Cedar Falls
June 29:	Cohran Concrete in Clarinda
June 29:	Bridge deck overlay near Corning
June 29:	Interstate 29 near Council Bluffs
July 19:	Highway 28 in Des Moines
August 10:	Highway 31 near Correctionville
August 11:	Highway 4, Pocahontas

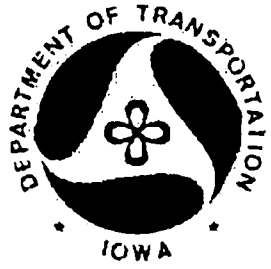
Arcot Naresh, Charles T. Jahren

Field Data Collection and Reporting Study: Section III Materials Acceptance Documents

Sponsored by the
Iowa Department of Transportation
Project Development Division and the
Iowa Highway Research Board

May 1997

Iowa DOT Project HR-377
ISU-ERI-Ames 96117



Iowa Department
of Transportation

report

FINAL

Department of
Civil and Construction Engineering
Iowa State University

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ABSTRACT

A review has been conducted of the current Iowa Department of Transportation (DOT) materials acceptance program from the construction field staff perspective. It has identified best practices of the field construction staff for collecting and tracking of materials acceptance documents. These best practices have been communicated to the developers of the SiteManager computer program. This program will be the standard construction administration program for the Iowa DOT.

The materials acceptance program could be improved by developing a materials classification system that will rate the relative importance of various materials. The rating system indicates why each material is important and allows the Iowa DOT to focus its acceptance efforts on the most important materials. A materials classification system was developed and pilot tested as part of this research project. The system uses expert input to set an appropriate level of scrutiny (primary, secondary, and tertiary) and provides a way of deciding whether test report is necessary or if a manufacturer's certification is adequate.

Although the recommendations of this report have not been implemented, they are being reviewed by the Iowa DOT Office of Materials' Material Rating and Acceptance Group. This group intends to recommend the implementation of a revised classification system that incorporates some of the ideas presented in this report. The revised classification system considers more factors and is directed more toward a weighted numerical approach. The system will also use a revised list of materials for classification (different groupings of materials). Materials experts will provide ratings.

INTRODUCTION

An effective material acceptance policy is an important aspect of construction administration. The material acceptance policy should ensure that the materials incorporated into the construction project are in reasonably close conformity with the specifications. These specifications were devised to ensure safety for transportation users and good performance for the facility. The material acceptance policy should be structured so that timely remedial action may be taken when problems occur. Abbreviations and variables are defined in Appendix A.

Current System

Iowa DOT accepts materials in the following ways (Iowa DOT I.M. 204):

- Sampling material at the source or at the job site and testing them in Iowa DOT labs.
- Sampling and testing by manufacturer (manufacturer certifies test results).
- Requiring a manufacturer's certification that the material meets specification.
- Requiring inspection by an approved testing agency (material supplier certifies that the material was properly inspected).
- Requiring the use of materials with approved brand names or approved lot numbers.
- Submission of shop drawings and catalog cuts for review by Iowa DOT Central Design Office.
- Inspecting visually in the field for conformance to plans, engineer's instructions and manufacturer's recommendations.

In cases where acceptance testing is not performed by Iowa DOT, the Iowa DOT conducts a limited number of monitor tests to verify manufacturer's tests and otherwise assure quality. In cases where source testing is used, supplemental tests may be conducted at the jobsite to check for degradation or misrouting of materials between the source and the jobsite.

Certifications are an important part of the materials acceptance policy. They are sworn statements regarding manufacturer's test results or the compliance of materials with the

specifications. They appear on test reports, invoices and delivery tickets. In some cases the certification is preprinted on the document. In other cases it is rubber stamped. Currently, certifications are classified according to four categories:

Type A. This certification is a manufacturer's test report that provides complete test results. This test report is associated with an identifiable lot of material. Examples of materials that are certified in this way include structural steel, reinforcing steel, prestressing strand, and seed.

Type B. This certification is also a manufacturer's test report. In contrast to the Type A certification, the Type B certification states that test results were within a certain range. The specific values of the test results are not given. The certification must be associated with an identifiable lot of material. Aluminum products are certified in this way because giving a range of test results rather than a specific number has been a long standing tradition in the aluminum industry.

Type C. This certification states that the material meets a particular specification. The specification number is reference in the certification. Structural plate pipe, latex emulsion, and clay tile are certified in this way.

Type D. This certification states that the material meets all applicable specifications without calling out the specification reference. Most materials are specified in this way. Examples include cement, fly ash, paint, corrugated metal pipe, asphalt cement, aggregate gradations, and plastic pipe.

Further information on certifications is available in Iowa DOT I.M. 204 Supplement. Iowa DOT policy is to have material acceptance documents submitted to the contracting authority before the materials are incorporated into the project. In some cases it is difficult to carry out this policy. There are several reasons for this difficulty:

- Documents are lost while being delivered and stored. This often happens when the truck driver cannot find the inspector at the time of delivery.
- Amount of material in place not known because of lapses in record keeping or errors in calculation.
- Amount of accepted material not known because of difficulties in matching documents with contract items and calculating quantities from documents.
- Required acceptance methods not understood.
- Dissemination of information about changes regarding approved brand and lot numbers not timely. When dissemination is timely, the updated information may not be filed during the busy season.
- Materials acceptance policy seems arbitrary to some members of the construction field staff.
- If the product is accepted by certification or approved brand name, reasons for collecting assurance samples are not understood by construction field staff. The assumption is that no further testing is needed. Actually a small amount of testing is needed to verify quality.

In some cases, projects are completed before all of the material acceptance documents have been collected. When this occurs, contract close-out is often delayed and substantial staff effort is expended to search for the documents. If the documents cannot be found, the contractor may be asked to submit further documentation. If the missing document is a certification, the manufacturer will often issue another certification to cover the materials that are in place. This satisfies the requirement for documentation, but raises questions about the integrity of the certification process because it is unlikely that the certification was associated with the in-place materials.

When contract close-out is delayed for material acceptance documents, the documents are often for materials that may be important, but do not appear to be critical. Such materials include temporary pipe, glass beads for traffic paints, and admixtures.

Document Flow

The proper delivery, storage, and retrieval of material acceptance documents are critical requirement for an effective material acceptance system. For most materials, documents move according to the flowchart in Figure 1. The original copy is sent to the Project Engineer and a copy of the certification is sent to the site. For certain materials, the I.M.s specify that additional copies should be sent to the contractor and the Transportation Center Materials Engineer (TCME).

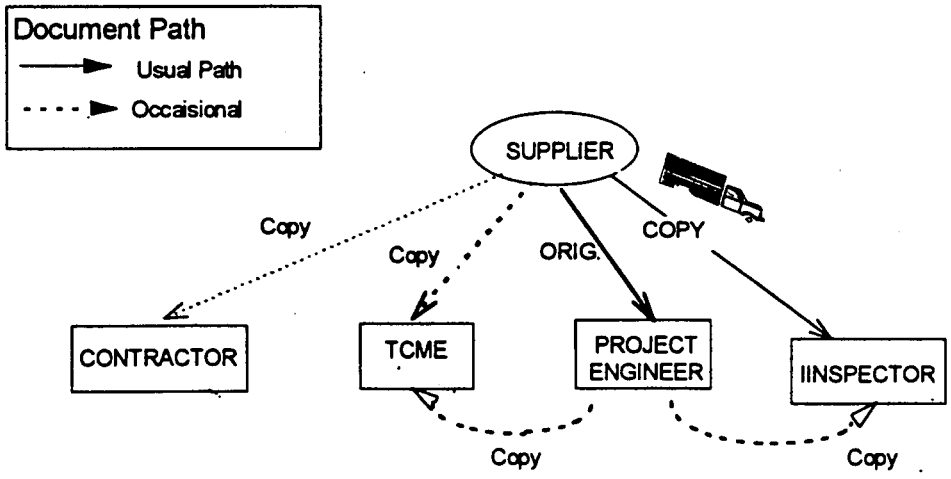

Figure 1. Document Flow

To ensure that everyone gets a copy of the documents, the project engineer may also make copies of the documents and send them to the TCME and the inspector. This can result in duplicate copies of certification. When the project is completed, the material acceptance documents are collected and an audit is conducted by the Project Engineer to make certain that documentation is available to cover all of the in-place materials. The audited close out package is checked by the TCME. If certifications are missing, there can be a delay in closing the contract. If it is not possible to account for a small amount to non-critical material, the situation must be explained in the close out documents and a price adjustment is made. When the documents are in order, the Transportation Center Construction Engineer (TCCE) signs Form 830436. This form closes out the contract and

certifies that all materials are in reasonable, close conformity with the plans and specifications (exceptions are listed). Form 830436 is then forwarded to the Office of Materials in the Ames Central Complex for review. Table 1 summarizes the duties of the Inspector, the Project Engineer, the TCME and Central Materials

POSITION	DUTY
Inspector	• Prepare bill of materials based on contract items • Prepare materials summary sheet • Collect and record materials certifications • Perform additional sampling and testing required by I.M. • Pay for materials after material acceptance requirements have been met
Project Engineer	• Pass documents and samples to inspector and TCME as necessary • Assist inspector in determining approved brands and approved lots • Audit project file for material acceptance requirements • Prepare Form 830436 • Make price adjustments in response to material acceptance problems
TCME	• Conduct independent assurance testing • Audit project files for material acceptance requirements • Recommend price adjustments in response to material acceptance problems • Review and sign Form 830436
TCCE	• Review and sign Form 830436
Central Materials	• Review Form 830436 and prepare letter to FHWA

Table 1. Duties for Processing Materials Acceptance Documents

RESEARCH METHODOLOGY

The research team was asked by the review committee to investigate the materials acceptance policy and make recommendations for improvement. The following methodology was used:

1. Meet with review committee to identify possible areas for improvement in materials acceptance policy. Also, identify offices in the state that have the best practices with regard to materials acceptance tracking.
2. Interview field staff and office of materials employees to find possible areas for improvement.
3. Visit offices to review and document best practices.
4. Develop a materials classification system that is easier to explain to the field staff.
5. Pilot-test the classification system.
6. Make recommendations.

The balance of the report summarizes the findings of the interview and office visits, describes a material classification system, provides recommendations and describes current implementation activities.

BEST PRACTICES

ISU researchers consulted with the review committee to identify offices that had developed the most effective methods for handling material acceptance documents. Two of the best practices identified were: (1) A method for grouping material acceptance documents that was developed by the Des Moines Resident Construction Office and (2) a database application that was developed in the East Central Iowa Transportation Center Region.

Material Groups

Certain inspectors in the Ames Resident Construction Office use a method of grouping materials in order to facilitate the tracking of material acceptance documents (Figure 2). This method was originally developed in the Des Moines Resident Construction Office. When materials are grouped, filing is more organized and missing documents are more easily identified. Then the supplier can be notified immediately instead of just before contract close-out. The following steps are involved in the process:

1. A contract item list (cover sheet) is prepared from the main bid item list (Figure 2). This list includes columns for the item description, the item code, and yes or no whether or not a certification is required.
2. Items are grouped when:
   - they are from the same source
   - they are usually certified on the same document. Many suppliers use a single invoice to certify more than one material
   - they are subgroups of a larger class of materials (e.g., all pipes together)
3. A materials approval report is prepared for each group. This report lists all materials in the group and has columns that show the required quantity. This sheet denotes the total quantity and the certified quantity to-date (Figure 2).
4. The certified material quantity is updated whenever material acceptance documents are received.
5. As the material certifications arrive, they are placed in the appropriate group folder.
6. Periodically, the quantity of material certified is compared to the quantity of material in-place. If there is a shortfall of certifications, immediate action is taken to remedy the situation.

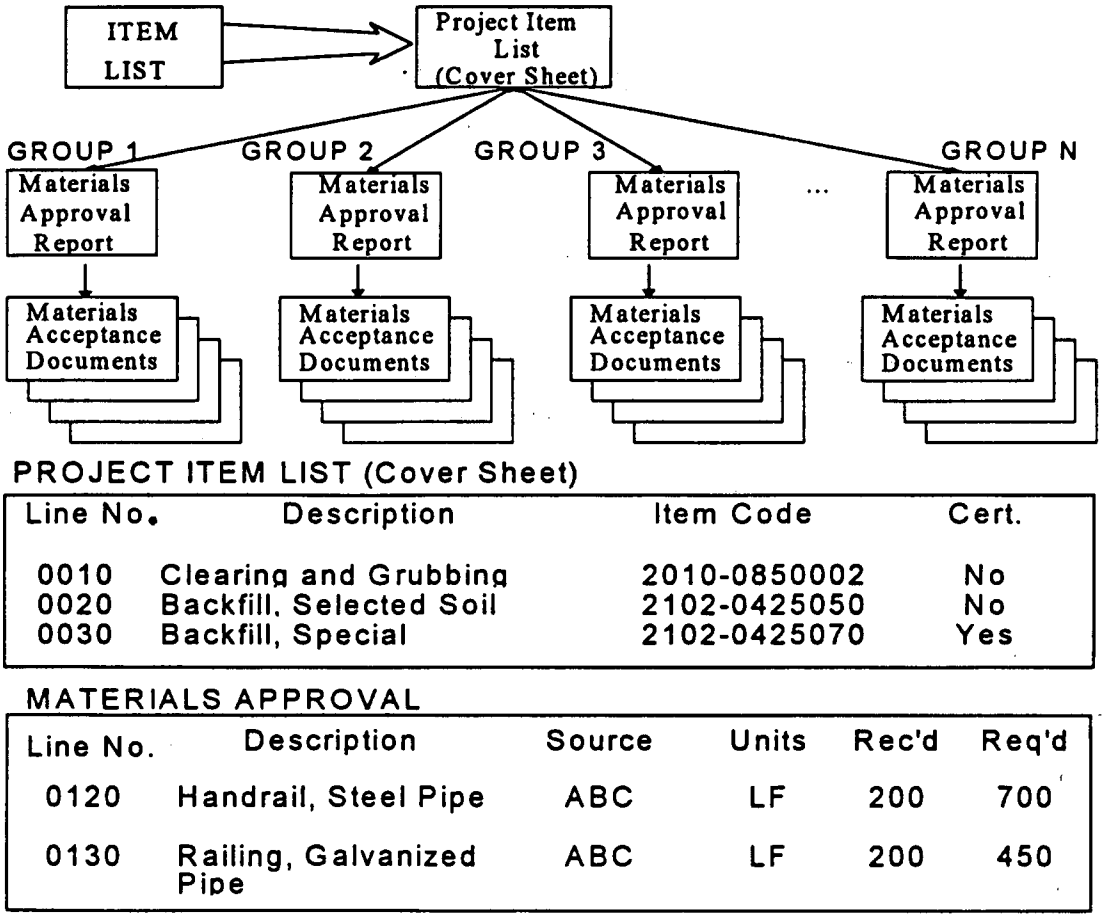

Figure 2. Materials Grouping System

Material Acceptance Database

One of the challenges of the current materials acceptance process is to identify the materials acceptance requirements for a contract with several items. The East Central Transportation Center has developed a database application that is used to identify bid items that require certifications. The application produces a report that gives the material acceptance criteria for each item in a contract. This application was programmed using a P.C. File for Windows.

An important part of the application is a master database that contains almost all of the regularly used Iowa DOT bid items. The material acceptance criteria for a particular

contract are extracted from the database by matching items with the Trns•port (formerly BAMs) item list. When an item is extracted the material acceptance criteria and the appropriate I.M. number come with it. Contract specific criteria may be added after the general items are extracted. The Trns•port bid item list is used to select contract items from the master item database.

Two types of reports can be generated from this application: Pre-Construction Reports and Field Inspector's Reports. Pre-Construction Reports allow Iowa DOT personnel to quickly review materials acceptance requirements before the contract starts. Field Inspector's Reports are similar to the material approval report described in the previous section on material groups. This type of report has columns that show the item measurement unit, IM number, Specification number, and material acceptance criteria. Inspectors make handwritten notations on the report to show the quantity of material certified and the quantity of material used. During the contract, this helps inspectors identify items that are missing material acceptance documents so they can quickly remedy the situation. The application does not place materials in groups similar to the previously described materials grouping systems.

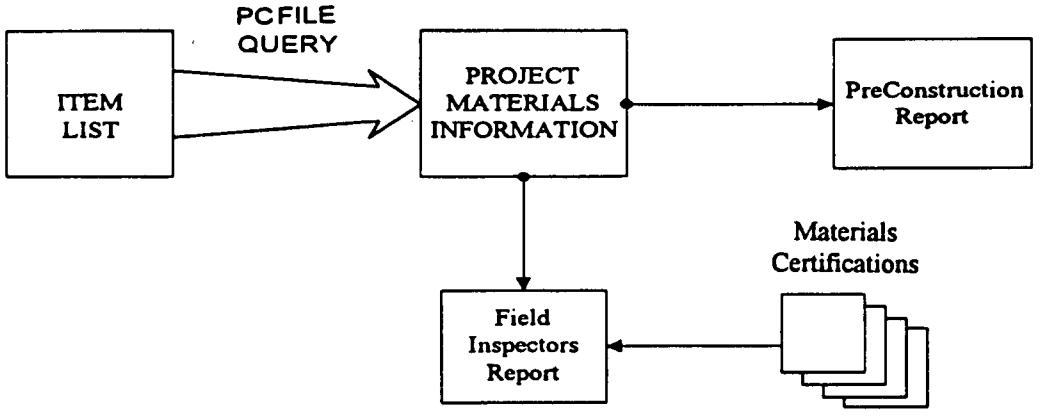

Figure 3. System in East Central Iowa Transportation Center Region

FRAMEWORK FOR CLASSIFICATION

During review committee meetings and the interviews with Iowa DOT personnel, many employees expressed concern that the current materials acceptance criteria were difficult to understand and seemed to be arbitrary. There was also concern that contract close-out was sometimes delayed by material acceptance problems. Furthermore, the materials involved in the acceptance problems did not seem to be critical to the safety or function of the project. It was concluded that it would be desirable to classify the materials. Classifications should be developed that reflect the consequences of failure and the uniformity of manufacturing. After the materials have been classified, a more rational material acceptance policy may be developed.

In developing the classification system, several factors should be considered.

- What are the consequences of failure?
  - Are there life safety issues involved?
  - If life safety issues are involved, is this material the only critical component that ensures safety?
  - How sudden could the failure be?
- What is the economic cost of failure?
- How much confidence can be place on the materials manufacturing uniformity.

For example, a bridge will collapse if certain bridge components fail. If steel fractures quickly, an inspection program cannot prevent the failure. Innocent people who are following the rules of the road could die or be injured. This is a case where the materials should be under close scrutiny.

Life safety issues are involved in reflective traffic signs. A motorist who cannot see the signs may drive off the road. However, in this case the traffic signs are not the only thing that contributes to such an accident. It is also necessary for the driver to be alert, for the vehicle to be in good mechanical condition, and for the road surface to be safe (not icy for example). Construction personnel also have the opportunity to inspect the job and correct the condition in case of low reflectivity. This is an issue where life

safety is involved, but proper performance of the material is not the only factor involved in keeping people safe. Fatal accidents could occur in locations where the traffic signs performs optimally. On the other hand, it is possible to have zero accidents on a stretch of road without traffic signs. This is a case where the level of scrutiny for the materials should match the contribution to safety.

If some items fail, a facility could be shut down that would result in substantial inconvenience to users. A bridge over a large river is an example of this. Suppose a defect is detected before it becomes a safety issue. However, defect causing shutdown would results in considerable hardship for the local area. Also substantial administrative time is required to remedy the problem and explain the situation to the public. It would be desirable to have a materials acceptance policy that will prevent such failures. In cases where there is a failure, despite our best efforts, it is desirable to have these efforts well documented.

If some items fail, the facility will not be completely closed. However, there will be a premature repair cost and inconvenience to the public while the problem is remedied. A pavement failure is an example of this. It is unlikely that life safety issues will be involved because the pavement can be repaired to maintain a safe driving surface. The potential cost and inconvenience are large and there will be a substantial administrative burden involved in explaining and remedying the problems.

In some cases, if substandard material is allowed, the consequences of failure may be quite small. However, even though a lapse of quality may not have safety and economic consequences, it may undermine the integrity of the DOT's method of selecting contractors. In the low bid system, it is assumed that all bidders are required to provide the same quality of work; therefore, it is assumed that the lowest bid is the best value. The DOT must provide uniform enforcement of quality requirements in order to maintain a level playing field among contractors. The fear is, contractors who cut corners on quality (including following material acceptance procedures) will have a lower cost structure if their behavior is not stopped. In extreme circumstances, the successful low bid contractor will be the one who is the least quality conscious. This would not necessarily

be true, however. In some cases quality conscious contractors have greater productive efficiency and able to underbid their competitors who are less quality conscious.

The confidence in the manufacturing uniformity of the material is important when setting its acceptance criteria. Materials that have high uniformity and, therefore, high confidence level may require less testing and documentation. The opposite would be true for a material that has low manufacturing uniformity.

In some cases, materials are only critical in certain applications. For example, a fracture critical structural steel bridge may be located where access and inspection are difficult. In this case, quality is a life safety issue. Quality may be more of a matter of economics for a highly redundant and easily inspected connection. Cement that will be used in prestressed girders is more critical than cement that will be used in sidewalks. But how do we know ahead of time where the cement will be used? When the final use of the material can be identified, it can be treated accordingly. Otherwise, it is probably better to err on the side of safety. Perhaps it would be better to keep track of where the material will be used, especially when it will be used in a critical location.

There are other questions that we need to ask is: Who is qualified to review the acceptance documents? Who can make judgments regarding test results and other information?

When acceptance documents must be reviewed by experts, the documents should be sent directly to the experts. The current cement certification procedure is an example of this. Lab test results are sent to the Office of Materials in the Ames Central Complex for review. The documents that are sent to the field certify that the lab tests have been taken and properly reviewed. Perhaps a similar method should be considered for other materials. A method of double checking can be developed for critical items where life safety considerations are an issue.

At the end of a contract, if material acceptance documents are missing, the question can be asked, "What is at stake?" If a life safety issue is involved, the material acceptance policy must be rigorously enforced. If the concern is maintaining the integrity of the construction administration system, a price adjustment could be made that would serve as a disincentive for similar lapses of documentation in the future. Then the contract

could be closed and Iowa DOT employees could focus their attention on more critical issues.

Classes

With the help of review committee and additional representatives from the Office of Materials, a method of classifying materials was developed. This method classifies materials into two main groups: 1) ones that require a test report (*TR*) along with delivery and 2) ones that require a certification only (*CO*). Each of these two classes have materials that are sub-divided in three subclasses: primary, secondary, and tertiary. The primary materials would receive the highest level of scrutiny. The level of scrutiny would have to be based on two criteria: the life safety index (*LF*) and a cost of failure index (*CF*). The manufacturing uniformity index (*MU*) would be used to decide whether the material requires a *TR* or *CO*.

Classification Strategy

The classification strategy involves surveying a group of experts to obtain ratings for the life safety index (*LF*), the cost of failure index *(CF)*, and the manufacturing uniformity index *(MU)*. The experts were presented with a list of materials. Then they rated each material by assigning a number between one and ten for each of the indices. The mean and standard deviation of each index were calculated. The statistical means for the three indices are used to classify the materials. The standard deviation indicates the amount of agreement among the experts.

Each sum of *LF* and *CF* (*CLF*) denotes the relative overall importance of a material. Materials with a high *CLF* would receive more scrutiny than materials with a low *CLF*. A low rating for *MU*, however, would indicate that the material has low manufacturing uniformity and high variation in performance. The following criteria were then set to classify materials during the pilot test:

PRIMARY: *CLF* greater than or equal to 14.

SECONDARY: Either *CF* or *LF* greater than or equal to 8.

TERTIARY: All other materials.

Each criterion was somewhat arbitrary and may be adjusted when the actual material classification is completed. If a material has a high *CLF* rating, it should also have a high manufacturing uniformity (*MU*) if it is to be accepted by certification only *(CO)*. On the other hand, materials with lower *CLF* might still be accepted by certification even though the *MU* is low. The *MU* cut-off limit is defined as the minimum value of *MU* allowed for a material to be classified as *CO*. The *MU* cut-off limit was determined by using the following equation:

MU [CUT-OFF] = *A* * *CLF*

where *A* is a constant that is selected to adjust the conservatism of the cut-off limit. Higher values of *A* classify more materials as *TR* (requiring test reports) and therefore make the classification more conservative.

For the first trial, the value of *A* was set to 0.50 (Figure 4). Suppose that a material received a *CLF* rating of 20. The material's *MU* cut-off would then be 10. Since it is not possible to have a *MU* greater than 10, this material would be classified *TR*.

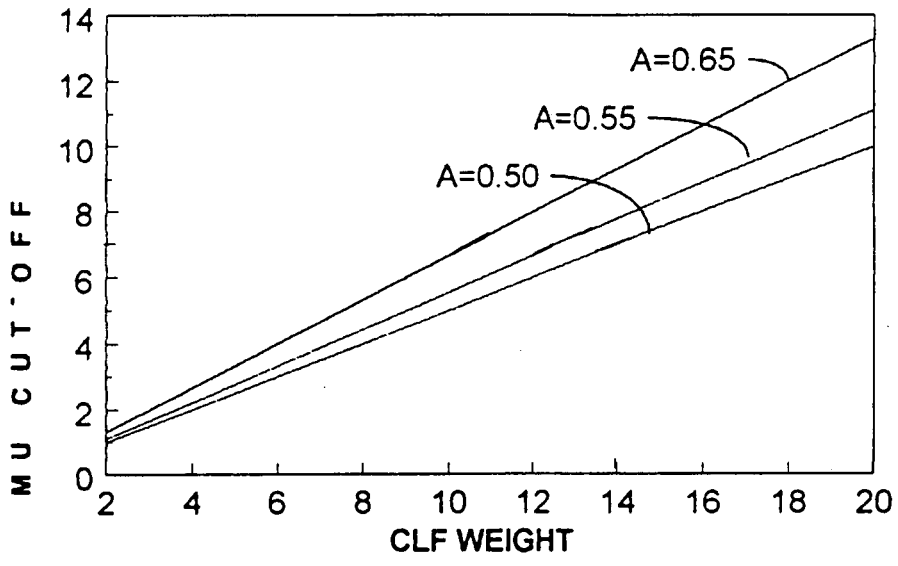

Figure 4. Material Classification Chart

Four more examples of the classification system are given below:

Example A: Structural steel received a rating of $LF = 10$, $CF = 10$, ($CLF = 20$) and $MU = 9$. This material would require a test report for any value of A that is suggested by this report (Figure 5).

Example B: Portland cement received a rating of $LF = 5$, $CF = 9$, ($CLF = 14$) and $MU = 7$. This material would require a test report for any value of A above 0.50 (Figure 6).

Example C: Fly ash received a rating of $LF = 5$, $CF = 8$, ($CLF = 13$) and MU = 7. This material would require a test report for any value of A above 0.55 (Figure 7).

Example D: Water reducer received a rating of $LF = 2$, $CF = 4$, ($CLF = 6$) and $MU = 7$. This material would not require a test report for any value of A that is suggest by this report (Figure 8).

It would be reasonable to classify materials with low CLF rating and high MU rating as approved brand. These are materials that are low priority for scrutiny and high uniformity. This suggests that once these materials are initially tested and approved they can be accepted by brand name for future contracts.

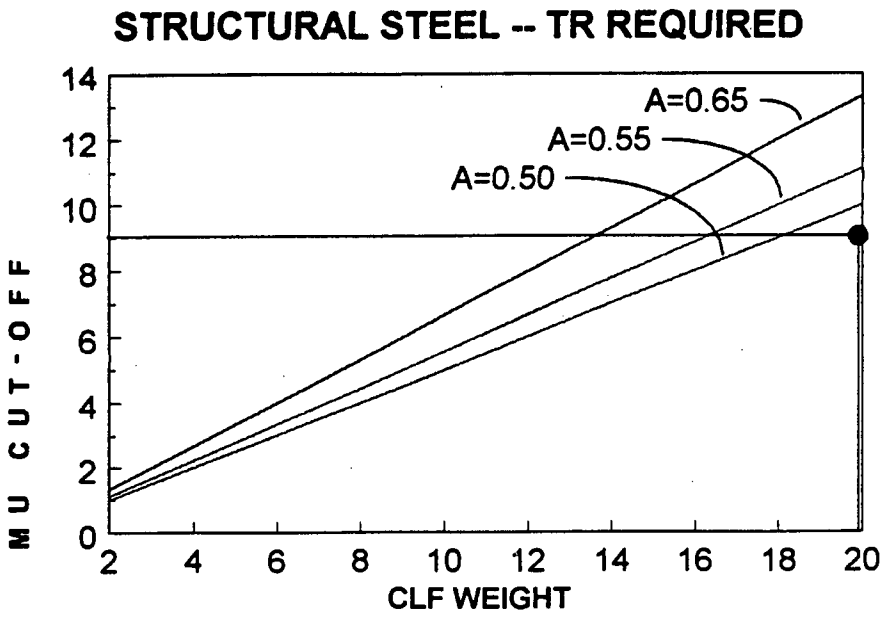

Figure 5. Example A

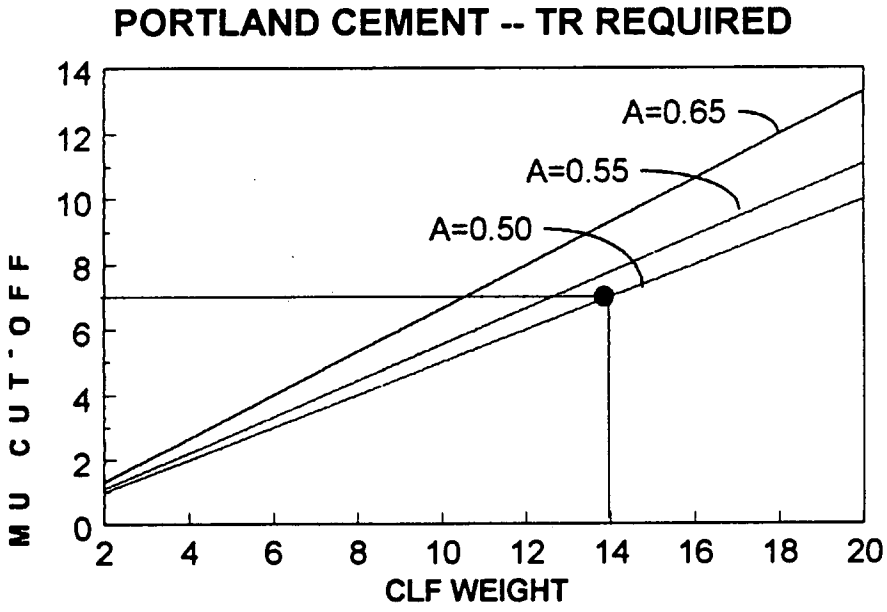

Figure 6. Example B

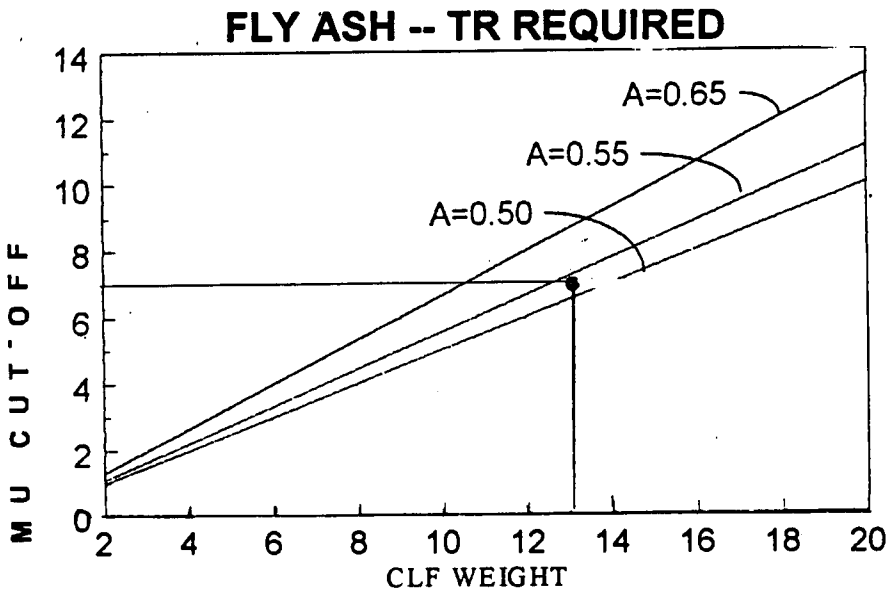

Figure 7. Example C

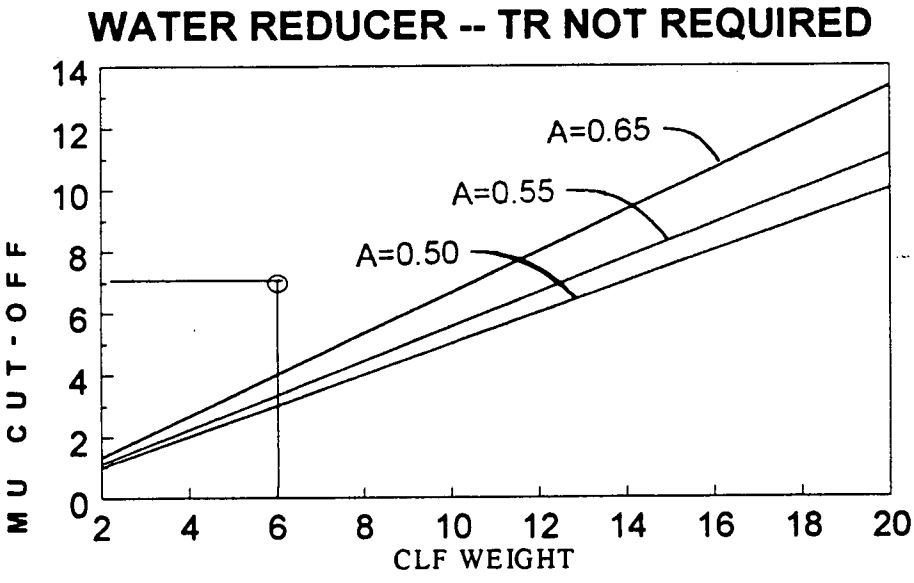

Figure 8. Example D

Pilot Testing and Implementation of Classification Strategy

ISU Researchers pilot tested the classification method. The review committee and a group of representatives from the Office of Materials served as the panel of experts. The panel rated a list of 180 materials. The results for selected materials are shown in Table 2.

The pilot test results classified portland cement concrete, asphalt cement, steel reinforcing and structural steel as primary materials. The averages and standard deviations are shown for the ratings of *LF*, *CF*, and *MU*. The standard deviation indicates the amount of agreement among panel members. Water reducer, flyash, and emulsified asphalt were classified as secondary materials. Burlap, caulking compound, seed, and sod stakes were classified as tertiary materials. The table shows how the requirement for a test report varies depending on the selection of the factor *A*. Structural steel and steel reinforcing would require a test report for any value of factor *A*. Test reports would not be required for caulking compound, seeds, and sod stakes. Whether or not a test report is required for portland cement, burlap, flyash, and asphalt cement depends of the value selected for factor *A*.

After the pilot test the Office of Materials formed the Materials Acceptance and Rating Group. This group is responsible for the actual classification of materials. They will obtain survey input from experts in the materials acceptance process.

Table 2. Pilot Test Ratings

MATERIAL	LF	CF	MU	LF+CF (CLF)		TR or CO? A=0.50	A=0.55	A=0.65
PORTLAND CEMENT								
Mean	6	9	7	13	Primary	CO	TR	TR
Standard Deviation	3.50	1.14	2.66					
WATER REDUCER								
Mean	2	4	7	6	Secondary	CO	CO	CO
Standard Deviation	1.63	2.35	2.79					
FLY ASH								
Mean	5	8	7	12	Secondary	CO	CO	TR
Standard Deviation	3.57	2.25	2.19					
CAULKING COMPOUND								
Mean	1	3	4	4	Tertiary	CO	CO	CO
Standard Deviation	0.52	1.77	2.79					
ASPHALT CEMENT								
Mean	4	9	8	12	Primary	CO	CO	TR
Standard Deviation	2.78	0.85	2.28					
EMULSIFIED ASPHALT								
Mean	2	7	7	9	Secondary	CO	CO	CO
Standard Deviation	1.09	1.66	2.24					
STEEL REINFORCEMENT								
Mean	8	9	8	16	Primary	TR	TR	TR
Standard Deviation	0.58	1.34	1.67					
STRUCTURAL STEEL								
Mean	10	10	9	19	Primary	TR	TR	TR
Standard Deviation	0.71	0.88	2.33					
SEED								
Mean	2	3	4	4	Tertiary	CO	CO	CO
Standard Deviation	0.84	1.84	2.59					
SOD STAKES								
Mean	2	3	4	4	Tertiary	CO	CO	CO
Standard Deviation	0.84	1.78	2.21					

STANDARDIZATION OF DOCUMENT FLOW

It would be desirable to standardize the flow of documents for the materials acceptance process. The recommended standard is shown in Figure 9. The supplier would send a copy of the acceptance documents to the office that is authorized to review the test results. This would be the TCME or a specialist at Central Materials. The material acceptance documents will also be delivered in the field with the materials.

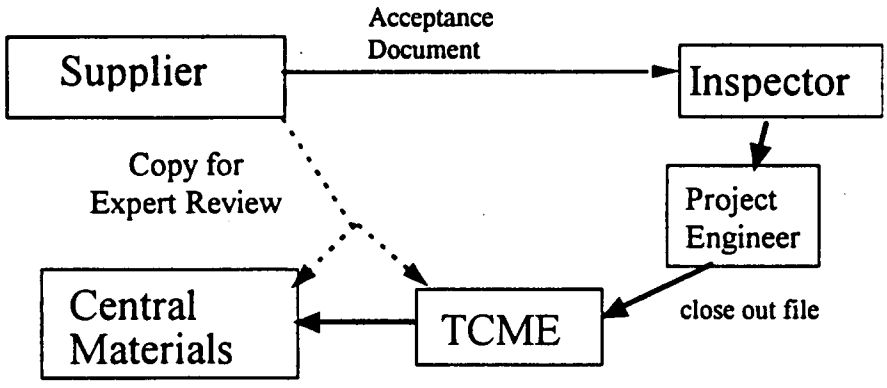

Figure 9. Proposed Standardized Document Flow

The inspector will look up the I.M. to find out whether or not a test report should be included with the certification. If the material is classified *TR*, the inspector would not accept the materials unless a test report accompanied the certification. Otherwise, a certification would suffice. At the end of the contract, all of the material acceptance documents would be assembled into a close-out package. The package would be forwarded from the inspector to the Project Engineer to the TCME to Central Materials.

By strictly adhering to this document flow, the number of duplicate certifications would be reduced. However, suppliers should be given clear instructions as to where to send documents. It would also be important to clearly identify the person who is in charge of reviewing test reports for each type of material.

IMPLEMENTATION

The results of this research will be implemented in two ways: First, many parts of the best practices identified in this report will be incorporated into a construction administration computer program that will be used by the Iowa DOT. Second, a work group has been appointed by the Office of Materials to implement the materials classification system described in this report.

Site Manager is a computer program that is under development by American Association of State Highway and Transportation Officials (AASHTO). It is a comprehensive construction administration program that will track contract progress, contractor payments, material test results, material acceptance documents, and civil rights information. Champak Natoram, Iowa DOT Materials Engineer, participated in many of the review committee meetings where material acceptance needs were discussed. He was also a member of an AASHTO committee that oversaw the development of the material acceptance modules for Site Manager. He used information from the review committee meetings to provide suggestions for the design of the Site Manager materials acceptance modules. Site Manager will be beta tested by Iowa DOT with the expectation that it will become a standard tool for construction administration activities. It will have the ability to track materials, look up material acceptance requirements, archive test results and track material acceptance documents.

Site Manager will be beta tested during 1997. Full implementation is expected to follow one or two years later. While waiting for full implementation of site manager, Project Engineers may improve their material acceptance documentation system by emulating the best practices described in this report.

The Office of Materials appointed the Material Acceptance and Rating Group (MARG) to implement the recommendations of this report. They will obtain ratings for *LF*, *CF*, and *MU* by sending questionnaires to experts in various classes of materials. Considering these ratings they will classify the materials and report their results to the Materials Quality Review Group (MQRG). The MQRG is charged with a materials inspection plan that is technically proficient, efficient, fair, and provides service to all affected parties. This group will completely revise I.M. 204 that is Iowa DOT's sampling

and testing plan. The plan will be revised to reflect recent changes in Federal requirements and the material classifications provided by the MARG group.

SUMMARY AND CONCLUSIONS

This report has provided a review the current Iowa DOT materials acceptance program. It has identified best practices of the field construction staff for collecting and tracking of materials acceptance documents. These best practices have been communicated to the developers of the SiteManager computer program. This program will be the standard construction administration program for the Iowa DOT.

The materials acceptance program could be improved by developing a materials classification system that will rate the relative importance of various materials. The rating system indicates why each material is important and allows the Iowa DOT to focus its acceptance efforts on the most important materials. A materials classification system was developed and pilot tested as part of this research project. The system uses expert input to set an appropriate level of scrutiny (primary, secondary, and tertiary) and provides a way of deciding whether a test report is necessary or if a manufacturer's certification is adequate.

Although the recommendations of this report have not been implemented, they are being reviewed by the Iowa DOT Office of Materials' Material Rating and Acceptance Group. This group intends to recommend the implementation of a revised classification system that incorporates some of the ideas presented in this report. The revised classification system considers more factors and is directed more toward a weighted numerical approach. The system will also use a revised list of materials for classification (different groupings of materials). Materials experts will provide ratings.

REFERENCES

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Instructional Memorandums. Project Development Division -- Office of Materials, Iowa Department of Transportation, Ames, Iowa.

APPENDIX A: LIST OF ABBREVIATIONS

Abbreviation	Meaning
AASHTO	American Association of State Highway and Transportation Officials
CF	Cost of Failure index
CLF	*CLF* = *CF* + *LF* (a combined index which indicates the importance of the particular material)
CO	requires Certification Only
DOT	Department of Transportation
FHWA	Federal Highway Administration
I.M.	Instructional Memorandum
LF	Life Safety index
MARG	Material Acceptance and Rating Group
MQRG	Materials Quality Review Group
MU	Manufacturing Uniformity index
TCME	Transportation Center Materials Engineer
TR	requires Test Report