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15. Supplementary Notes

Study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Research Study Title: "Bridge Inspection Training"

16. Abstract

Bridge inspection training was aided by the use of computers in this study. This process was evaluated after ten inspectors had completed thirty-two hours of computer-aided training (CAT). Recommendations were made for the use of these CAT packages.

Public Works Training Division installed the hardware and software.

The submodules covered substructures, superstructures, trusses, bearings, flooring systems, signing, bridge approaches, legislation reports, safety, tools, forces, materials, and inspection exercises.

The bridge inspection training takes 1½ to 3 days to complete and there is a pretest and a posttest. Only one student at a time can participate in the program.

The study concluded that the program is a very effective training method and does a good job of training on the topics that it covers.

17. Key Words	18. Distribution Statement
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FINAL REPORT

Research Study 582

RTAP Study 2-10-88-582

COMPUTER-AIDED BRIDGE INSPECTION TRAINING

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Public Works Training Division
Texas Engineering Extension Service

February 1990

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I. INTRODUCTION

This report documents our evaluation of the Compuvid Computer-Aided Training Program for Bridge Inspection. The Public Works Training Division (PWTD) agreed under the terms of this contract to

- provide ten prospective bridge inspectors with 32 hours of computer-aided training (CAT) using the Compuvid bridge inspection software
- evaluate the results of the training and make recommendations for the use of the CAT packages.

PWTD training specialists installed the hardware and software. Hardware items included the following

- IBM PS/2-50Z computer
- compatible color graphics monitor
- touch screen accessory
- video interface unit
- video tape player-recorder
- video monitor
- parallel printer

The PWTD worked closely with Compuvid representatives to ensure prompt installation and start-up of the software. This software consisted of thirteen submodules described in the following section.

The PWTD selected 10 students from local government entities which had previously requested bridge inspector training. Each student completed the

training program with the assistance of the project coordinator who monitored the project and evaluated the training technique for effectiveness and for possible applications to other areas such as construction inspection or transportation-related training.

A profile of the students who completed the training is included in Appendix A.

The following draft report deals in detail with:

- o installation and start-up problems and their solution
- o analysis of the most effective equipment use
- o evaluation of the effectiveness of the CAT package
- o techniques and procedures which could be used with the CAT package to provide more comprehensive training
- o other possible uses of computer-aided training
- o cost effectiveness of the method under study
- o recommendations for future training.

II. INSTALLATION AND START-UP PROBLEMS

In the interest of conserving time on this project, bids on all equipment (hardware) were requested prior to the effective contract date. Orders for all hardware and software were placed immediately thereafter. Through communications with Texas A&M University System Purchasing, we subsequently discovered that some hardware items were not covered by the initial purchase request and orders for these items were placed in early October, 1988.

Hardware Installation

After delivery of all hardware, we found that the BCD-1000 video interface unit was not compatible with the IBM PS/2-50Z. The interface unit was returned and a replacement unit acquired.

When the replacement hardware was received, we discovered that an additional serial port was required for the computer and special connector cables were necessary for VCR, video monitor and interface unit connections. Also, a special adaptor and connector cable were required for connection of the touch screen accessory.

All hardware and cables were finally assembled and connected on Feb. 14, 1989.

Software Installation

Part of the software package was delivered in early December, 1988. Module 4 was first delivered in early January, 1989, but the disk was defective and replacement discs were not received until February 14. No instructions or documentation were available at that time, but through telephone conversation with Compuvid, we were able to run and test the system on Feb. 14, 1989.

The project coordinator proceeded through the course material February 14-17 in preparation for the delivery, installation and orientation visit by the Compuvid technician.

Orientation

Mr. Greg Strass delivered three copies of "Compuvid Systems, Inc. Interactive Video System Instructor Manual," Version 4.0, February 22, 1989, and provided installation and startup orientation on February 22 and 23, 1989.

Mr. Strass corrected several errors in the review exercises during this orientation session. Numerous spelling and typographical errors were mentioned to Greg during the session; he indicated that corrections would be made shortly by running a spell-check program and corrected disks furnished in the near future. New disks have been furnished, but numerous errors in the software persist. Examples of these are shown in Appendix B.

III. REVIEW OF MOST EFFECTIVE METHODS OF USING THIS EQUIPMENT

This is an interactive video training program consisting of four modules, each of which is divided into submodules further divided into lessons.

Training Sequence

The program may be run in the "index" mode, which allows the student to progress through the various lessons in any sequence, or the "linear" mode, in which the student must follow a prescribed lesson sequence. The linear mode is much faster and allows the instructor to prescribe the sequence that will best facilitate comprehension.

The original software presented the submodules in the following order.

Module	Submodule	Title
	1	Substructure
	2	Superstructure
	3	Trusses
1	4	Bearings
	5	Flooring Systems
	6	Signing
	7	Bridge Approaches
	1	Legislation and Reports
2	2	Safety
	3	Tools
3	1	Forces
	2	Materials
4		Inspection Exercises

The project coordinator rearranged the order of the submodules as follows.

Module	Submodule	Title
	1	Legislation and Reports
1	2	Safety
	3	Tools
2	1	Forces
	2	Materials
	1	Substructure
	2	Superstructure
	3	Trusses
3	4	Bearings
	5	Flooring Systems
	6	Signing
	7	Bridge Approaches
4		Inspection Exercises

A complete outline of the course, including lesson titles, is included in Appendix C.

Training Time

The program is relatively simple to run and takes between 1 1/2 and 3 days to complete, depending upon the individual student's reading and comprehension speed. The times stated above include approximately 3 to 4 1/2 hours for registration, introduction, pretest, and posttest. The program is limited to use by only one student at a time

Actual videotape time is approximately 7 hours, and the minimum time required to progress completely through the program is between 7 1/2 and 8 hours, depending upon mode of operation and degree of concentration. Most of the video segments are of 35 mm color slides and in many cases the slide quality is poor. We feel that the program would be much more effective with the use of professional quality video.

We believe that the optimal use of this program for training bridge inspectors is as a familiarization course for beginning inspectors and/or as a refresher course for inspectors that have not been involved in bridge inspection for some time.

This program appears to be an excellent tool for introductory bridge inspection training; however, it does not appear to cover the subject areas in sufficient breadth or depth to meet the requirements of "a comprehensive bridge inspection training course."

IV. EFFECTIVENESS OF TRAINING

This program is a very effective training method in that it does a good job of teaching students the subjects that it covers. The option that allows students to review any section they do not understand or find confusing facilitates comprehension of the material presented.

Each submodule includes a review exercise at the end. This exercise presents eight multiple-choice questions and advises the student of the number of correct responses. This allows students to review if they are not comfortable with the information presented. These review exercises select the eight questions randomly from twelve questions on the submodule.

In order to measure student learning, we reproduced all 144 questions from the 12 review exercises and administered this as a pretest and posttest for each student. These test questions are included in Appendix D.

For the ten students completing the program to date, the average scores are as follows:

1. Pretest 61.8%
2. Review Exercises 82.8%
3. Posttest 84.7%

The figures shown are the percentage of correct responses and indicate an improvement of 21% between pretest and review exercises and an improvement of 22.9% between pretest and posttest.

The extremes on the tests were as follows.

	low	high
pretest	44.4	72.2
review	71.9	93.2
posttest	74.3	93.1

Each of the ten students scored higher on both the review exercises and posttest than on the pretest. Six of the ten students scored higher on the posttest than on the review exercises which indicates that the review exercises themselves serve as a teaching tool.

The overall improvement in scores as well as demonstrated knowledge of bridge member function, terminology, condition, deterioration, etc. indicates highly effective training.

V. TECHNIQUES AND PROCEDURES TO COMBINE THIS PROGRAM WITH OTHER TRAINING TO PROVIDE "A COMPREHENSIVE BRIDGE INSPECTOR TRAINING COURSE"

After observing students progress through this program and periodically discussing the training materials with them, we believe that the program could be coupled with on-the-job training as a member of a bridge inspection team to meet the requirements of "A Comprehensive Bridge Inspector Training Course" based upon FHWA's Bridge Inspectors Training Manual-70.

As stated earlier, we feel that the most beneficial use of this program is

- as a familiarization course for beginning inspectors and,
- as a refresher course to be taken periodically by inspectors who have not been active in bridge inspection continually for a substantial period of time.

For relatively inexperienced inspectors, a review of selected portions of this program would likely be very beneficial if performed immediately prior to bridge inspection. In particular,

- the portions on reports, safety and tools would be good reminders on a recurring basis, and
- portions on steel, trusses, concrete and timber would be effective inspection planning reviews immediately prior to inspecting a specific type bridge.

VI. OTHER POTENTIAL USES OF EQUIPMENT AND TRAINING TECHNIQUES

We are enthusiastic at this point regarding the potential of this equipment and training method for transportation-related training.

It appears that many transportation-related training programs would lend themselves to presentation with this equipment and method. However, the major impediment at this point is that we have not identified any other available programs. It seems that software should be available to develop such programs, but we know of none that are presently on line.

The most likely reasons that other programs of this type are not available are:

- the high cost of software,
- relative complexity of the hardware,
- specific technical problems (computer programming, video production, video editing, etc.), and
- lack of time and/or funding for specific course development.

Few organizations have sufficient expertise in all of these technical areas as well as instructional capabilities and experience in training program development to readily and rapidly produce high quality, reliable, effective training programs in various transportation-related areas.

Possible areas for development of transportation-related training programs to utilize this equipment and technique are as follows:

1. Construction Inspection
2. Maintenance Procedures
3. Rehabilitation Methods
4. Traffic Control
5. Computer Applications
6. Management Practices, Techniques, Programs, and Implementation (Maintenance Management, Equipment Management, Pavement Management, etc.)
7. Pavement Design
8. Road Surface Inventory and Condition Rating
9. Drainage Design
10. Construction Surveying/Job Control

This is only a beginning as this training method and equipment has the capability to present training in almost any subject and to any degree of depth and detail desired.

VII. COST-EFFECTIVENESS:

ECONOMIC FEASIBILITY OF THIS EQUIPMENT AND TRAINING METHOD

Initial evaluation indicates that this is not a cost-effective training method. However, there appears to be relatively good potential for development and growth that could promise cost-effective training.

The system's capacity to train only one student at a time coupled with the desirability of having a knowledgeable instructor available to answer questions, evaluate learning, monitor the hardware and software, and keep the system operating presently precludes this from being cost-effective

training though not all of the instructor's time is required and other work can be accomplished while a student is working on the program, it is necessary to have someone available to assist if a problem occurs with either the hardware or software.

The relatively high cost of both hardware and software make it doubtful that this method will soon become a very cost-effective, economically feasible alternative to more conventional training methods.

As more training program software becomes available, it appears that a training center with multiple training stations organized such that one instructor could monitor, assist, and supervise 15 or 20 students working on different programs might make this technique economical. We feel that it would be essential that the instructor have fundamental knowledge of all training programs under his supervision.

We believe that training for individuals and/or small groups might become economically feasible under the training center concept in the future if sufficient programs and hardware become available; however, it appears that the relatively high cost of software and hardware may prevent economic feasibility unless hardware can be organized to simultaneously run several students on different programs.

The station hardware for this contract cost approximately $8,600.00. We spent approximately $2,000.00 more than the minimum essential in order to have computer, printing, and video cassette recording capability beyond the minimum requirements. A training center configuration probably could be arranged for approximately $5,000.00 to $6,000.00 per training station. There is a possibility that the per station hardware cost could be further reduced by computer networking; however, more investigation would be required prior to making specific recommendations along this line.

The software for this program cost in excess of $40,000.00 including the installation and start-up visit. Obviously, this is an extremely high cost for single student capability. We have not investigated quantity discount as we feel that considerable improvement and expansion of the program should be required prior to its extensive use.

VIII. RECOMMENDATIONS FOR FUTURE TRAINING

Consideration should be given to continuing the use of this program on an indefinite, interim basis pending major revisions in the FHWA Bridge Inspection Training Manual-70. Should this be done, we recommend that negotiations be initiated for expansion and improvement of the program.

Specific areas of expansion should include but not necessarily be limited to the following:

1. Fracture Critical Member Identification
2. Continuous vs. Simple Span Loads, Reactions and Stresses
3. Bridge Identification and at Least Minimal Coverage of Arch, Suspension, and Cable-stayed Structures,
4. Segment on Multiple Box Culvert, Multiple Pipe Installation, Long Span Arches and Other Comparable Structures Classified as Bridges,
5. Specific Discussion of Delamination of Concrete and Effect of Reinforcing Steel Corrosion on Structural Capacity

Specific areas of improvement should include but not necessarily be limited to the following:

1. Capability to update computer materials and correct errors.
2. Eliminate excessive background noise from videotapes.
3. Replace video segments that show erroneous information and/or have such poor lighting that students cannot see the item discussed.

IX. CONCLUSION

Interactive computer-video training has tremendous potential. New developments in videodisc rather than videotape seem to offer several advantages. This is an area of great promise that needs continual observation, implementation, evaluation and improvement to maximize the potential benefits.

APPENDIX A

PROFILE OF COURSE PARTICIPANTS

Job Classification

Engineer	4
Engineering Technician	5
County Commissioner	1

Employer

County	7
City	2
Consulting Engineer	1

Age

20-29	3
30-39	2
40-49	3
50-59	1
unknown	1

Sex

Female	1
Male	9

APPENDIX B

The following pages illustrate typographical and other on-screen errors present in the software.

The Notebook/Clipboard format for on site inspection activity:

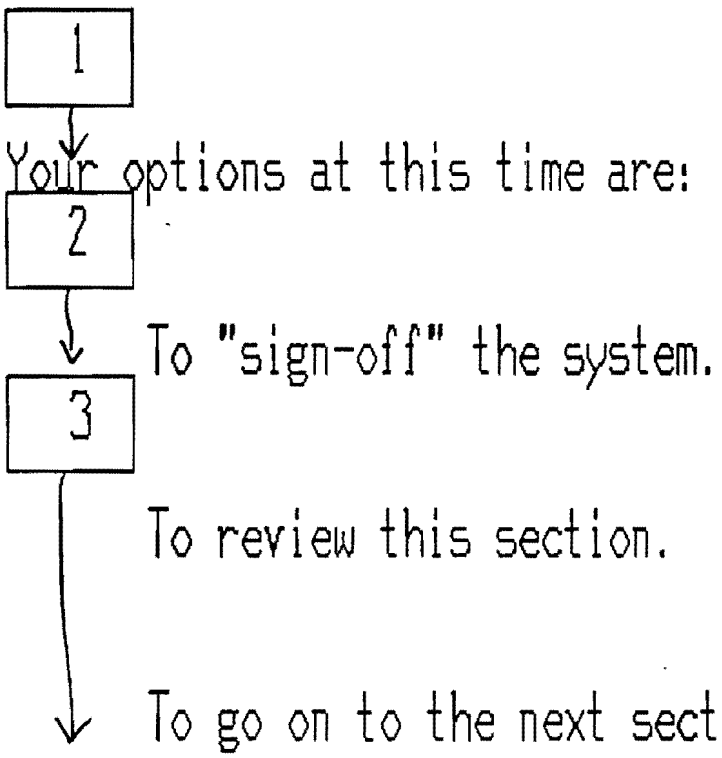
1	provides and outline for inspection activity.
2	assures that no component is overlooked.
3	may consist of checklist sheets, plain or grid paper and outline drawings.
4	all of the above.

The zero through nine numerical rating scale for describing bridge component conditions:

1	was developed by the Federal Highway administartion.
2	provides for uniform reporting of "as found" conditions on the S.I. & A. Report.
3	Can be used to indicate adjectival ratings of the inspector for items 58 - 72 on the S.I. & A. report.
4	all of the above

You have just completed the section:

On the first attempt, you got Ø of Ø correct.



Touch the box associated with your choice.

Structure and Inventory Report Form

Purpose

Design

III. Structural Data - items 27 - 57

- Physical characteristics description
- Age - date built
- Design load
- Average daily traffic (ADT)
- Physical dimensions
- Horizontal and vertical clearance
- Safety features

Opts

CONTINUE

APPENDIX C

The following is a detailed outline of the course including the lesson titles covered in each submodule.

BRIDGE INSPECTION

Tape No.	DESCRIPTION
940	1. LEGISLATION & REPORTS 1. Inspection legislation 2. Report forms, etc. 3. Prepare for inspection 4. Comprehensive reports 5. Component rating & coding 6. Report documentation 7. Review exercise
950	2. SAFETY 1. Bridge Inspector 2. Planning Safe Inspections 3. Vehicles and safety 4. Safety clothing 5. Safety equipment 6. Hazardous conditions 7. Safety summary 8. Review exercise
960	3. TOOLS 1. Basic hand tools one 2. Basic hand tools two 3. Large & special tools 4. Review exercise
970	4. FORCES 1. Forces, motions, vectors 2. Torque & rot. moments 3. Dead & live loads 4. Forces, stress & strain 5. Stress types 6. External forces 7. Foundation Movement 8. Calamities 9. Stream Bed/Channel Changes 10. Review Exercises
980	5. MATERIALS 1. Concrete bridges 2. Steel bridges 3. Timber bridges 4. Review exercise

Tape No.	DESCRIPTION
910	6. SUBSTRUCTURE 1. Introduction to substructures 2. Abutment parts 3. Abutment types 4. Pier parts 5. Pier types 6. Bents, parts, types 7. Review exercise
910	7. SUPERSTRUCTURE 1. Introduction to superstructure 2. Beams and Girders 3. Concrete Beams 4. Steel Beams 5. Review Exercise
910	8. TRUSSES 1. Introduction to trusses 2. Truss patterns 3. Truss terminology 4. Truss materials 5. Truss stress 6. Connections & fasteners 7. Welded connections 8. Pin conn. & problems 9. Review exercise
920	BEARINGS 9. 1. Introduction to bearings 2. Moveable types 3. Fixed bearings 4. Bearing inspection 5. Review exercise
920	10. FLOORING SYSTEMS 1. Introduction to floor systems 2. Bridge deck 3. Expansion joints 4. Safety features 5. Review exercise

Tape No.	DESCRIPTION
920	11. SIGNING 1. Introduction to signs 2. Function of signs 3. Proper location 4. Sign examples 5. Review exercise
930	12. BRIDGE APPROACHES 1. Introdcution to approaches 2. Approach problems 3. Slope pavements 4. Safety features 5. Review exercise
990	13. INSPECTION EXERCISES 1. Introduction 2. Concrete bridge 1 3. Concrete bridge 2 4. Steel bridge 1 5. Steel bridge 2 6. Timber bridge 1 7. Timber bridge 2 8. Summary

APPENDIX D

The 144-question test compiled from the review exercises and administered as a pretest and posttest is reproduced on the following pages.

Mark only one answer

___ 1. Bridge structure loads are transmitted through weak soil layers to firm underlying strata by wood, steel, or concrete shafts called:

A. foundations
B. columns
C. pilings
D. piers

___ 2. That portion of an abutment that may serve as a support for the approach slab is the:

A. foundation
B. backwall
C. bridge seat
D. breast wall

___ 3. The horizontal member of a bent that is designed to distribute the bridge load to the columns is called the:

A. cap
B. bracing
C. foundation
D. pile

___ 4. Pile bents are characterized by piles:

A. resting on a common foundation
B. used as support columns
C. erected at an angle
D. beneath a pier foundation

___ 5. A shoulder abutment is also known as a:

A. stub abutment
B. semi stub abutment
C. pile abutment
D. full height abutment

___ 6. Which of the following is NOT a function of wingwalls?

A. restrain embankment fill
B. deflect water and floating debris
C. support the breast wall
D. prevent erosion

___ 7. Substructure support may be accomplished by all of the following EXCEPT:

A. footings
B. wing walls
C. compacted soil friction on pilings
D. direct bearing of pilings on natural rock

___ 8. The most common type of abutment footing is:

A. reinforced concrete slab
B. pile bent
C. natural rock
D. reinforced concrete breastwall or stem

___ 9. Which of the following is not a part of a pier:

A. stem or column
B. backwall
C. footing
D. bridge seat

___ 10. Substructure units of a bridge provide for:

A. movement of the span
B. adequate support for the superstructure
C. free passage of water and traffic beneath the structure
D. all of the above

___ 11. A pier that is characterized by a relatively long cap and a single support shaft is called a:

A. dumbbell pier
B. narrow wall pier
C. hammerhead pier
D. web pier

___ 12. Piles, when employed beneath abutment or pier foundations may provide support by all of the following except:

A. direct bearing on solid rock strata
B. compacted soil friction
C. retaining embankment fill
D. both A & B above

___ 13. The simplest type of bridge superstructure is the:

A. steel through girder span
B. concrete box span
C. reinforced concrete slab span
D. beam and girder span

___ 14. For relatively long spans, concrete slabs may be supported by:

A. steel beams
B. timber beams
C. reinforced concrete beams
D. A and B above

___ 15. If traffic moves between main supporting members of a bridge the structure is called a:

A. deck supported span
B. through type span
C. beam and girder span
D. steel deck girder span

___ 16. If the main support members of a span are composed of concrete the span may be designated as:

A. a reinforced concrete span
B. a reinforced concrete "I" beam span
C. a reinforced "T" beam span
D. any of the above

___ 17. In pretensioned concrete beams, reinforcing bars are tensioned

A. before pouring of the concrete
B. after the beams are positioned
C. to reduce stress in the beam
D. none of the above

___ 18. The most common point of deterioration of concrete beam and girder spans is the:

A. lateral bearing surface
B. bottom traction surface
C. joints between adjacent girders or deck slabs
D. web cross section

___ 19. The design advantage of steel box girders over reinforced concrete girders is:

A. on-site fabrication
B. long uninterrupted span length
C. high torsional resistance
D. low strength to weight ratio

___ 20. A deck supported span

A. limits bridge traffic height
B. requires suspended traffic decks
C. is supported by beams or girders beneath the deck
D. is characterized by a reinforced, poured concrete slab

___ 21. Built up plate girders:

A. require lateral bracing for stability
B. are usually used for spans over 70 feet
C. may be welded, bolted, or riveted together
D. all of the above

___ 22. The superstructure of a bridge consists of:

A. all parts of the bridge supported by the substructure
B. the beams and girders
C. all parts of the traction surface
D. piers/piles/bents/beams/girders/deck/main support members

___ 23. The superstructure of a bridge:

A. transfers the load to the substructure
B. is a through girder type structure
C. is cast in place after the substructure is in place
D. requires main support members of steel or concrete

___ 24. Beam and girder bridges are designated by the:

A. length of the span
B. method of prestressing
C. method of joining the steel components
D. material and cross section shape of main support members

___ 25. Trusses, rather than beams and girders are often used for long spans because they:

A. can be cantilevered
B. provide great stability without excessive dead load
C. offer less wind resistance
D. provide live load height limitations

___ 26. Which type of truss does not limit the vertical height of traffic:

A. pony truss
B. deck truss
C. half through truss
D. all of the above

___ 27. In analyzing the stress in pony and through trusses:

A. the upper chord is usually in tension
B. the lower chord is usually in tension
C. the lower chord is usually in compression
D. none of the statements above are generally true.

___ 28. In a truss, counters (if present)

A. are always under tension
B. extend laterally between the top chords
C. extend diagonally between the lower chords
D. are always under compression

___ 29. Flat steel plates which join truss members together and increase the lateral strength of the truss are called:

A. web members
B. built up members
C. gusset plates
D. weld plates

___ 30. In a truss, diagonals, counters, and verticals are often referred to as:

A. web members
B. cord connectors
C. panel points
D. span sections

___ 31. If a truss is of uniform construction, the dead load is divided evenly amoung the:

A. counters
B. intermediate panel points
C. bottom chords
D. sway braces

___ 32. Truss members may be joined by:

A. welding
B. pins secured with threaded nuts
C. riveting to gusset plates
D. all of the above

___ 33. The vertical members at each end of a pony or through truss:

A. are always pin connected to the floor beam
B. are always under compression stress
C. are always under tension stress
D. must be latticed for lateral stability

___ 34. Which of the following statements about stress analysis of truss members is NOT a true statement?

A. stress acts along the longitudinal axis of the member
B. individual truss members are considered rigid (not flexible)
C. truss members are connected by frictionless pins
D. forces in truss members always cause compressive stress

___ 35. A live load moving on a through truss supported span:

A. are supported equally by the panel points of the truss
B. creates temporary overstressing of the truss
C. creates ever changing stress at all panel points of the span
D. creates the most stress at panel farthest from its position

___ 36. Which of the following is probably not evidence of truss overstressing?

A. bent or misaligned members
B. sheared or missing rivets or bolts
C. floor beam corrosion
D. gusset plate cracking

___ 37. The resistance to motion of two surfaces in contact is proportional to

A. temperature
B. the force pressing the surfaces together
C. the length of the span
D. the dead load of the span

___ 38. Bridge bearings:

A. permit limited longitudinal movement of span
B. permit limited vertical movement of the span
C. transmit superstructure loads to the substructure units
D. all of the above

___ 39. Elastomeric pad bearings:

A. are usually placed between rollers to reduce friction
B. are a type of fixed shoe bearing
C. may be preformed of semi-solid plastic elastomer
D. permit unlimited vertical span displacedment

___ 40. Sliding friction if changed to rolling friction in:

A. rocker and metal plate bearings
B. roller and elastomeric pad bearings
C. roller and metal plate bearings
D. rocker and roller type bearings

___ 41. Fixed shoe bearings:

A. anchor one end of a span against longitudinal movement
B. permit rotation of a span
C. resist lateral horizontal movement of a span
D. all of the above

___ 42. Rocker bearings rotating on a bearing pin secured to the superstructure should be tilted...

A. toward the fixed bearing when the temp. is below 30DegF.
B. away from the fixed bearing when the temp. is below 30DegF
C. toward the fixed bearing when the temp. is above 80DegF.
D. none of the above

___ 43. That type of bridge bearing which permits longitudinal expansion by a shearing action of the bearing material is the:

A. sliding plate bearing
B. roller bearing
C. elastomeric pad bearing
D. rocker bearing

___ 44. Lateral movement of cantilevered bridge spans employing hanger type bearings is usually limited by special devices called

A. sway braces
B. anchor pins
C. double rockers
D. wind locks

___ 45. Which type of bearing is essentially a heavy pinned hinge?

A. the double rocker bearing
B. the fixed shoe bearing
C. the elastomeric pad bearing
D. the bronze plate bearing

___ 46. "Frozen" or non functioning bearings may cause:

A. span misalignment
B. abutment misalignment
C. pier misalignment
D. all of the above

___ 47. Which type of bearing is often found beneath the main support members of relatively long multispan bridges that are not at right angles to the abutments?

A. roller bearings
B. hanger plate bearings
C. fixed shoe bearings
D. none of the above

___ 48. The extent of "rocking action" of a span employing rocker bearings is limited by the:

A. bearing pin
B. anchor pin
C. radius of the bearing pin
D. vertical displacement

___ 49. Which of the following is NOT a function of the floor system of a bridge:

A. supports the deck
B. provides a smooth traction surface
C. provides rigidity to the structure
D. distributes the live load evenly to main support members

___ 50. Floor system members that are crosswise to and are supported by the main supporting members are called:

A. stringers
B. diaphragms
C. floor bearms
D. spreaders

___ 51. Normally, the deck of a bridge structure rests directly on floor system members called:

A. stringers
B. end floor beams
C. diaphragms
D. main support members

___ 52. Which of the following statements about diaphragms is NOT true?

A. diaphragms improve rigidity of the span
B. diaphragms extend laterally between stringers
C. concrete diaphragms extend longitudinally between floor beam
D. truss diaphragms are often used where weight is a factor

___ 53. Which of the following statements about bridge decks is NOT true? Decks...

A. protect the floor system of a bridge
B. may be made of concrete/timber/steel plate or steel grates
C. may also be the main supporting of a bridge
D. none of the above statements are true.

___ 54. Bridge bracing is a system of flexural tension-compression members that form truss type framing. Which statement about bracing is NOT true?

A. bracing may extend diagonally between supporting members
B. bracing is not designed to add rigidity to a span
C. bracing can withstand lateral and longitudinal stress.
D. bracing resists stress of vibration and wind

___ 55. Low safety walls designed to safely direct traffic into bridge traffic lanes are called:

A. guide strips
B. parapets
C. railings
D. safety lanes

___ 56. Bridge decks must be designed so that water does not collect and remain on the bridge. Which of the following does not promote drainage?

A. scuppers, drains, and downpipes
B. crowning of the deck surface
C. curbs and gutters
D. none of the above

___ 57. Bridge span expansion of several inches is usually provided by:

A. siding plate expansion joints
B. narrow openings to promote drainage
C. asphalt sealant
D. parallel steel angles

___ 58. Wheel impact damage to abutting edges of concrete slabs may be reduced by:

A. overfilling the joint with sealant
B. removing the sealant to promote water drainage
C. using premolded neoprene expansion joint compound
D. reinforcing the edges with parallel steel angles

___ 59. Pedestrian walkways and bridge railings:

A. are important span strength components
B. provide for pedestrian safety and convenience
C. reduce the effectiveness of the span
D. are supported be the curbs or parapets

___ 60. Floor system stringers:

A. cannot be prestressed concrete
B. cannot be cast in place
C. cannot be directly connected to the diaphragm
D. cannot extend laterally between main supporting members.

___ 61. Regulatory signs which alert drivers to traffic laws or regulations are usually

A. black on yellow backgrounds
B. black on white backgrounds
C. diagonal in shape
D. none of the above

___ 62. Warning signs which alert drivers to hazardous conditions are usually

A. black on yellow backgrounds
B. black on white backgrounds
C. reflectorized white
D. all of the above

___ 63. The parallel stripes on bridge end markers

A. are horizontal
B. slope downward toward the shoulder
C. slope downward toward the traffic lane
D. are never painted on the bridge structure

___ 64. Glass or plastic reflectors on or near the bridge to guide the traffic onto the span are called:

A. lane stripes
B. bull's eye
C. delineators
D. pole markers

___ 65. Which of the following statements about bridge weight limits signs is not true? Weight limit signs...

A. are regulatory signs
B. should be placed so as to allow heavy vehicles to reroute
C. are usually black on white background
D. are usually painted on the structure

___ 66. Vertical clearance signs

A. are regulatory signs
B. are absolutely necessary for through girder spans
C. cannot be mounted directly on the structure
D. should be placed so as to allow vehicle rerouting

___ 67. Which of the following is NOT an important function of bridge signing?

A. warning of hazardous conditions
B. protection of the structure
C. public safety
D. none of the above

___ 68. Narrow bridge signs are:

A. used when span width is less than approach roadway width
B. usually painted on the structure
C. regulatory signs
D. required by Federal law

___ 69. When inspecting a bridge, the inspector should note and record all of the following characteristics of signing EXCEPT:

A. presence and legibility of signs
B. visibility and purpose
C. condition, location, support, color and size
D. none of the above

___ 70. Signs that provide information such as routes, destinations, historical or geographical points of interest, etc., are known as:

A. map and location signs
B. guide signs
C. traffic signs
D. route and direction signs

___ 71. Bridge signs may be attached to the superstructure or supported near the bridge. Which of the following is not an appropriate support for a bridge sign?

A. metal post
B. two timber posts
C. a fence post in advance of the span
D. a guard rail near the abutment

___ 72. Which of the following is NOT a consideration for the of bridge signing?

A. type of warning
B. approach roadway configuration
C. age of the structure
D. bridge location

___ 73. Which of the following is NOT a function of the bridge approach?

A. provide a smooth roadway-to-bridge transition
B. restrict stream erosion
C. provide for passenger and vehicle comfort
D. maximize roadway safety

___ 74. Bridge approach guardrails:

A. guide wayward vehicles safely onto the bridge
B. protect bridge ends from vehicle collision.
C. may have flared ends
D. all of the above

___ 75. The joint between the approach slab and the abutment:

A. may be sealed to prevent erosion of supporting material
B. must be either sliding plate or open finger joints
C. must be capable of supporting wide shoulders
D. must not be level with the span

___ 76. The most common approach to span transition fault is:

A. approach span length B. lack of approach width
C. vertical displacement D. shoulder erosion

___ 77. Which of the following may cause vertical displacement of a fill-supported approach slab?

A. embankment material voids are reduced
B. increased loading forces moisture out of supporting fill
C. embankment fill shrinks or voids are created by erosion
D. all of the above

___ 78. Relief joints at the roadway end of the approach are designed to compensate for:

A. vertical shear
B. concrete pavement "creep"
C. embankment settlement
D. span-expansion

___ 79. The relatively thin surfacing of the approach embankment to prevent erosion is called:

A. the approach shoulder B. the drainage apron
C. the slope pavement D. water shed

___ 80. A deck span that is lower than the approach slab may be caused by:

A. abutment settling B. embankment swelling
C. both "A" and "B" D. neither "A" nor "B"

___ 81. Bridge approach shoulders should be:

A. lower than approach slab edge
B. higher than approach slab edge
C. the same width as the span
D. none of the above

___ 82. Open, or semi-open approach spans are:

A. usually of reinforced concrete supported by fill
B. usually supported by columns or piers
C. characterized by wide shoulders
D. none of the above

___ 83. An approach grade greater than two and a half percent is dangerous because

A. vehicles tend to "bounce" onto the span
B. vehicles tend to "fly" off the span
C. neither "A" nor "B" above
D. both "A" and "B" above

___ 84. The bridge approach shoulder should:

A. adequately support the open approach
B. be wide enough for vehicles to stop "off road"
C. be surfaced with non-porous aggregate to aid drainage
D. be laterally graded to a maximum of 2 1/2 percent

___ 85. Every bridge is identified by a seven digit number. The first three digits:

A. indicate the type of structure
B. identify the county in which the bridge is located
C. refers to the length of the structure
D. cannot be the same for any two bridges

___ 86. Inventory data:

A. defines type, location and maintenance responsibility
B. is usually prepared from records, maps, plans, etc.
C. includes a permanent bridge ID number.
D. all of the above

___ 87. Bridge appraisal

A. refers to the cost of the structure
B. is based on permanent records
C. requires "on-site" inspection and evaluation of condition
D. depends on the size and type of structure

___ 88. The Structure Inventory and Appraisal report form:

A. is completed each time the structure is inspected
B. uses a numerical coding system of the U.S. Dept. of Trans.
C. may include photographs, narratives, drawings, etc..
D. all of the above

___ 89. The Comprehensive Field Report:

A. documents the current condition of the structure
B. is retained locally
C. establishes priorities for repair and maintenance
D. all of the above

___ 90. If minor repair or maintenance by local crews is required the component condition should be rated:

A. good
B. fair
C. poor
D. critical

___ 91. Comprehensive Report documentation may consist of all except:

A. photographs
B. narratives and graphs, maps, etc
C. S.I. and A. forms
D. outline drawings

___ 92. Regular or routine bridge inspections:

A. Promote public safety and convenience
B. extend the usable life of the structure
C. aid in establishing repair and maintenance priorities
D. all of the above

___ 93. An advantage of using 35mm slide photographs rather than instant (polaroid) prints for condition documentation is:

A. screen projection for analysis of detail
B. the ability to write directly on the photographs
C. verification of the documentation at the time of inspection
D. there is no need for flash attachments

___ 94. When using prepared outline drawings for recording documentation of bridge defects:

A. no dimension are needed because drawings are not to scale
B. component identification is not required
C. identification and dimensions are needed for analysis
D. drawing is not included in comprehensive report.

___ 95. Components or conditions that are rated poor:

A. are numerically rated 5 or 6.
B. require further documentation for the comprehensive reports
C. require minor repair or maintenance by local crews
D. all of the above

___ 96. The notebook format for bridge inspection:

A. reduces the risk of overlooking a component or condition
B. provides an outline for inspection activity
C. requires subjective evaluation by a competent inspector
D. all of the above

___ 97. Subjective evaluation of bridge component integrity is based on:

A. objective observation
B. accurate measurement
C. testing and investigation results
D. all of the above

___ 98. When inspection activity requires restricting a two lane span to a single lane of traffic:

A. portable traffic lights must be set at the span mid-point
B. inspection vehicle's flashing lights should be on
C. flagmen should be stationed at bridge ends
D. detour signs should be used to redirect traffic

___ 99. Bright colored safety vests and protective headwear should be worn:

A. only when working at heights over 20 feet
B. to increase inspector visibility
C. only when working in or above water
D. to inform approaching drivers that the activity is official

___ 100. To be effective for preventing injury from free fall or impact, the safety lanyard must:

A. extend from inspector's safety belt to a firm support
B. be able to support the weight of a man and his tools
C. have smooth snap rings at each end that provide closure
D. all of the above

___ 101. Whenever climbing or descending ladders:

A. remove gloves for a positive grip
B. secure the safety lanyard
C. always face the ladder
D. use pulleys and ropes

___ 102. When working in water:

A. the depth should be determined by probing prior to entering
B. flotation vests must be worn
C. at least one other person should be present
D. all of the above

___ 103. Safety belts and secured lanyards or lifelines are absolutely required

A. when working at heights over 10 feet
B. when working at heights less than 10 feet
C. when working over water or above moving traffic
D. all of the above

___ 104. Safety shoes:

A. should have rubber or non-electrical conducting soles
B. must be high shoes rather than oxford type
C. should not have protective toe caps
D. all of the above

___ 105. Safety glasses

A. must have shatterproof lenses
B. may be ground to prescription
C. must be worn when chipping/scraping/chiseling/brushing
D. all of the above

___ 106. Which of the following are reasonable safety precautions to take when it becomes necessary to enter a confined space?

A. checking for noxious gasses before entering
B. use of an air pack
C. constant radio/telephone communication to the "outside"
D. all of the above

___ 107. Birds, especially pigeons, are a threat to the health and safety of the bridge inspector because:

A. their nests conceal bridge component deterioration
B. they often attack inspectors
C. airborne fungus and bacteria from droppings are infectious
D. they always carry lice

___ 108. On-site bridge inspection is a public trust that requires essential skills of:

A. observation, interpretation and integration
B. interpretation, observation and resolution
C. observation, interpretation and communication
D. healthly respect for, but not a fear of, heights

___ 109. The three common enemies of tool life are:

A. dirt, moisture, and identification
B. moisture, impact and wear
C. dirt, identification and wear
D. dirt, moisture and impact

___ 110. The tool commonly used for determining right angles or as an accurate depth gauge is the:

A. level
B. folding rule
C. combination square
D. calipers

___ 111. The level may be used:

A. to establish horizontals
B. as a straight edge
C. to determine verticals
D. all of the above

___ 112. The common hand tool that is responsible for more minor accidents than any other tool is:

A. the screwdriver
B. the jackknife
C. the ice pick
D. the hammer

___ 113. Screwdrivers:

A. should not be struck with the hammer
B. should have non-electrical conducting handles
C. can be used for probing narrow recesses
D. all of the above

___ 114. A large jackknife is an indispensible tool for all of the following uses except:

A. marking reference points on steel members
B. probing small cracks
C. checking timber members
D. general cutting purposes

___ 115. Large distance elevations, reference points for alignment and angles of approach inclines are usually measured with a device called:

A. a caliper
B. a transit
C. a plumb bob
D. none of the above

___ 116. The lead line is commonly used for:

A. determining the width of river channels
B. determining the approach length
C. determining channel current
D. determining water depth

___ 117. The most important documentation equipment consists of:

A. marking crayons or chalkboard and chalk
B. an assortment of punches and scratch awls
C. a reliable camera and flash attachment
D. sight lines, levels and a plumb bob

___ 118. Which type of hammer can be most effectively used for removal of metallic corrosion or loose concrete?

A. the ball peen hammer
B. the standard claw hammer
C. the sledge hammer
D. the chipping hammer

___ 119. Which of the tools listed below are usually not used for determining misalignment?

A. the plumb bob
B. the level
C. the half cell
D. the inclinometer

___ 120. Pliers and wrenches are designed for gripping and torquing. The tool should be adjusted so that:

A. the gripping surfaces are parallel
B. the handle(s) comfortably fit the hand
C. the serrated surfaces are perpendicular to each other
D. the leverage is maximum

___ 121. A force acting on a bar tends to rotate it about its point of support in a counterclockwise direction. This turning effect is called:

A. a clockwise moment
B. a counterclockwise moment
C. the rotational equilibrium
D. none of the above

___ 122. A rotational moment is equal to the size of the force times the:

A. distance the object moves
B. fulcrum or point of support
C. distance from point of application to the fulcrum
D. distance the bar moves

___ 123. A uniform bridge span is supported at each end by a force equal to:

A. the live load of the span
B. the center of gravity
C. one half the dead load of the span
D. the weight of the span

___ 124. A live load moving across a simple span:

A. creates a constant torque equal to the load's weight
B. creates changing rotational moments on the span
C. is equally supported at each end of the span
D. is primarily supported by the support farthest from it

___ 125. Deformation or change in shape or dimension due to the application of an applied force is called

A. strain B. stress
C. elasticity D. strength

___ 126. Any loss of section of a bridge member under stress:

A. reduces the unit stress in the member
B. increases the maximum unit stress in the member
C. decreases the working stress in the member
D. represents a loss of strength in the member

___ 127. The most common bridge calamity is:

A. vehicle impact
B. fire on or beneath the structure
C. flooding of rivers and debris impact
D. earthquakes and severe storms