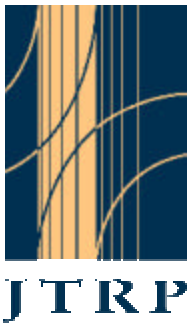

FIELD GUIDE FOR THE POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Prepared for the
Indiana Department of Transportation, INDOT

by

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under the
JTRP Contract No. 2377

March 2000

DISCLAIMER

While the information presented in this field guide is believed to be correct, authors and the sponsoring agencies assume no responsibility for its accuracy or for the opinions expressed herein. The material presented in this publication should not be used or relied upon for any specific application without competent examination and verification of its accuracy, suitability, and applicability by qualified professionals. Users of information from this publication assume all liability arising from such use.

PREFACE

In 1999, the Indiana Department of Transportation contracted, through the Joint Transportation Research Program at the School of Civil Engineering in Purdue University, with Professor's Julio A. Ramirez, Robert J. Frosch and Mete A. Sozen to develop a training program for post-earthquake safety evaluation of highway bridges.

Professor's Julio A. Ramirez, Robert. J. Frosch, Mete A. Sozen, and Dr. A. Murat Turk, post-doctoral research associate, prepared this manual and an accompanying training video that was produced by the Center of Instructional Services of Purdue University. Overall view and guidance for the project was provided by B. Rinard, W. Dittelberger and J. Thompson of the Indiana Department of Transportation.

The principal investigators gratefully acknowledge the participation of Prof. Marc Eberhard from University of Washington, Seattle in the preparation of this material.

Bridge damage examples and pictures were reproduced from; EQIIS Image Database, Earthquake Engineering Research Center (EERC, University of California at Berkeley), Kandilli Observatory and Earthquake Research Institute (KOERI, Bogazici University, Istanbul), National Center for Research on Earthquake Engineering, Taiwan.

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1. INTRODUCTION

1.1. Object and Scope

It is acknowledged that the most damaging earthquake within the state took place on September 27, 1909 near the Illinois border between Vincennes and Terre Haute. Both nonstructural and structural damage occurred to the buildings in this area, and it was felt strongly in the southwest of Indiana including Indianapolis. Other significant earthquakes have been felt in the state with epicenters occurring in the southwestern corner. Indiana has also experienced damage from earthquakes originating in neighboring states.

Unfortunately, due to the long recurrence interval of strong earthquakes in Mid-America, a large inventory of structures has accumulated without explicit consideration of seismic resistance. Highway bridges are a significant component of this inventory. The seismic vulnerability of highway bridges constructed within the state, especially in southwestern portion of Indiana, presents a problem of serious consequences.

The seismic history of the region, and the classification of the Southwestern portion of Indiana as AASHTO Seismic Performance Zone 2, has resulted in an increased awareness regarding the need to be prepared against the potential threat presented by earthquakes. As one of the first steps in the development of seismic policy for the state, the Indiana Department of Transportation has decided to prepare highway personnel for the post-earthquake safety evaluation of bridges. Since the highway system is an essential component of the lifelines to a community following an earthquake disaster, it is important to quickly assess its safety and functionality, and provide temporary retrofits to quickly restore transportation routes. A post-earthquake bridge inspection plan with properly trained personnel is a key component of the disaster response plan to restore quickly the transportation routes in order to permit the access of relief and reconstruction assistance.

The main purpose of this field guide is to provide INDOT personnel of various backgrounds with a rapid and effective methodology for the post-earthquake safety inspection of bridges and roads in Indiana. This methodology is intended to promote and maintain the uniformity of the inspection as much as possible while assessing and rating bridge and road damage. It is likely that the first personnel to be dispatched or that will reach damaged structures will not be engineers. Furthermore, depending on the extent of the damage that may occur, it is possible that there will not be an adequate number of experienced engineers to survey every structure.

This field guide contains the material necessary for a systematic safety evaluation of bridge structures and roads for a wide range of INDOT personnel. In the field guide, the necessary material is arranged according to two inspection levels. Level 1 inspection consists of the rapid visual evaluation of the bridges and roads in the affected area to establish obviously unsafe structures and roads. The Level 1 section of the field guide is intended for INDOT personnel with a broad range of backgrounds. Level 2 inspection consists of a more in-depth safety evaluation of bridges and roads, as well as temporary repair and long-term monitoring techniques. This segment is designed specifically for INDOT engineers. The Level 2 inspection team will be expected to make a more detailed structural and geotechnical post-earthquake condition assessment of the bridge. The inspection team may choose to reduce the speed of incoming vehicles as they approach the bridge, to restrict access only to emergency vehicles, or to close the bridge entirely to traffic. The team may also consider, where appropriate, if temporary shoring or other strengthening and long term monitoring measures are required.

The organization and the management of the post-earthquake inspections are under the jurisdiction of INDOT, unless declared a State Disaster by the Governor and taken over by SEMA, and it is outside the scope of this field guide

1.2. Level 1 Inspection

The main objective of the Level 1 Inspection section is to prepare INDOT personnel with a wide range of backgrounds for the visual safety inspection of highway bridges and roads immediately following an earthquake. The purpose of the Level 1 inspection is to restrict the traffic on unsafe bridges (Red Tag) and roads, to identify those that are safe (Green Tag), and to indicate those in need of further evaluation (Yellow Tag). The information gathered also will be used to develop rough estimates of the extent of the damage. This information will be available to prioritize the work of Level 2 teams. Level 1 inspection is deemed appropriate for all bridges and roads in the affected area immediately after the earthquake. The Level 1 inspection consists of aerial view and/or drive through. Appropriate actions should follow the inspection. Bridges deemed unsafe must be red tagged and closed to traffic. Roads that cannot be traversed must be identified. Finally, the geographical extent of the damage should be identified.

The outline of the Level 1 components of the field guide are:

- Brief description of the seismology of Indiana
- Illustration of typical Indiana bridges
- Examples of collapsed bridges and damaged roads
- Preparations necessary for Level 1 inspection
- Teams
- Description of bridge closing procedures
- Suggested equipment and inspection form
- Review/Assignments

1.3. Level 2 Inspection

The top priority of the Level 2 inspection should be the inspection of all the yellow tagged bridges and roads identified during the Level 1 inspection. In addition to closing unsafe bridges and identifying routes that cannot be traversed, the Level 2 inspection team will make a more detailed assessment of the bridges in the affected area. The assessment should include

geotechnical and structural aspects. Teams must contain INDOT personnel under the supervision of an experienced INDOT engineer. The main objective of the material related to the Level 2 inspection in this field guide is to prepare the team members to make a proper structural and geotechnical assessment of the condition of bridges following an earthquake. These teams can further refine the conclusions about the Level 1 inspection yellow tagged bridges, restrict their use for only emergency vehicles, or open the bridge to traffic. At the same time, after completing the inspection of Yellow tagged bridges, Level 2 teams should inspect the Red tagged bridges in critical routes to determine if they may be put back into operation with in-house repairs. This inspection team will also provide recommendations for short-term repair and whether it should be conducted in house or a consultant is needed. It will also indicate if shoring and monitoring of the damaged bridges is needed. This inspection will be conducted using ground transportation.

The following is an outline of the items in this field guide pertaining to the Level 2 inspection:

- Examples of damage to typical Indiana bridges
- Preparations necessary for Level 2 bridge assessment
- Teams
- Necessary equipment and inspection form
- Techniques for temporary repair and long-term monitoring techniques
- Review/Assignments

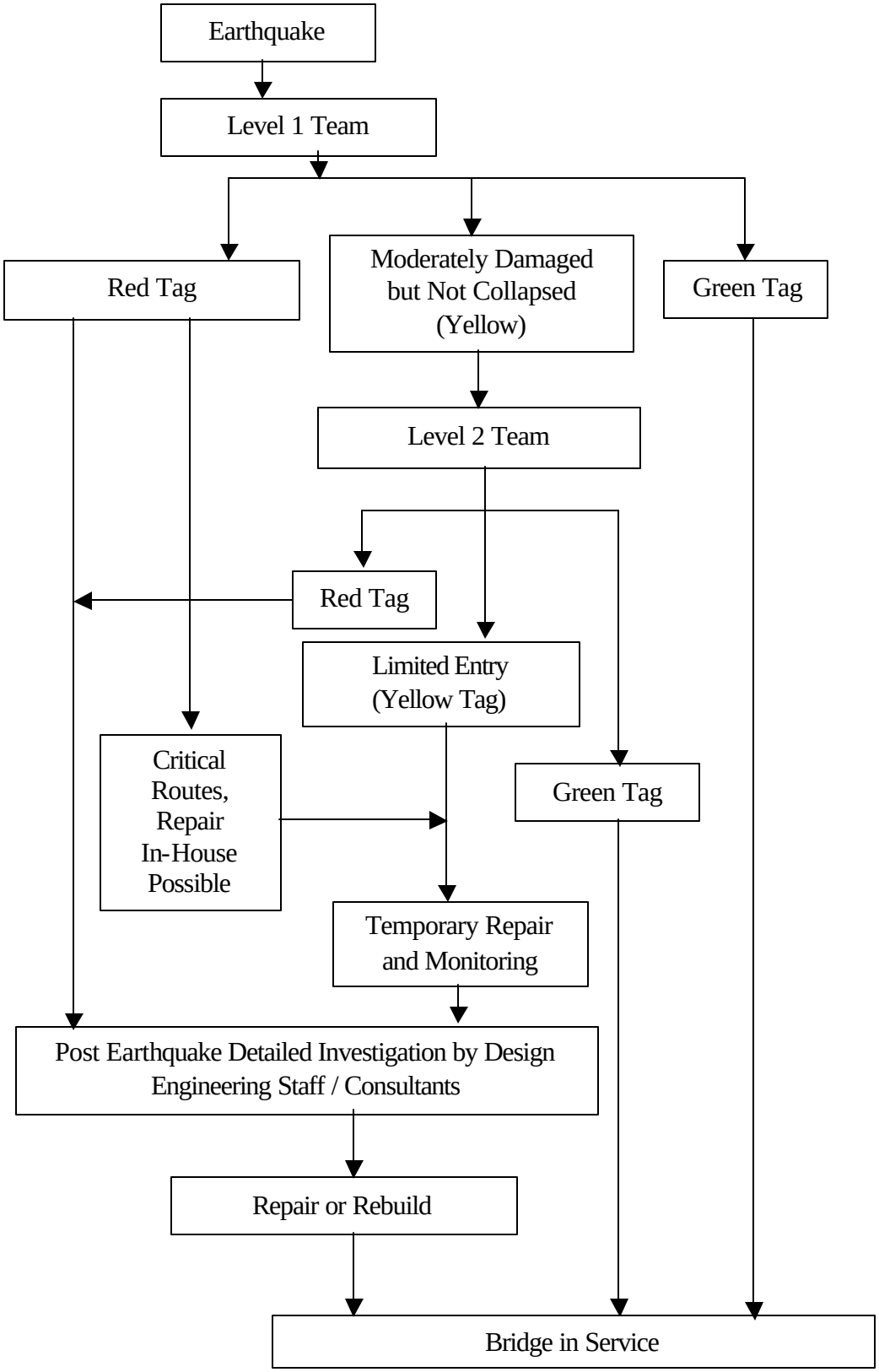


FIGURE 1.1 Flow-chart of Post-Earthquake Response Assessment

2. INDIANA BRIDGE STRUCTURES

In this chapter, typical examples of highway bridges located in the Vincennes district of Indiana, which is considered to be in the area of seismic risk, are shown (9). They are classified according to their structural properties (8). In addition, the types of bearings are also illustrated.

ARCHES:

- Unreinforced Concrete Arch

- RC Arch Open Spandrel

- Reinforced Concrete Arch

- Precast Concrete Arch Underfill

SLABS:

- Metal Pipe Arch

- Reinforced Concrete Slab Underfill

- Multi-Plate Arch

- Continuous Reinforced Concrete Slab

- Steel Girder

- Precast Concrete Slab Underfill

GIRDERS:

- Reinforced Concrete Girder

- Steel Box Girder

- Riveted Plate Girder

BEAMS:

- Prestressed Concrete Box Beam-Spread Boxes

- Prestressed Concrete I-Beam

- Continuous Prestressed Concrete I-Beam

- Steel Beam

- Composite Continuous Steel Beam

TRUSSES:

- Steel Pony Truss

- Steel Through Truss

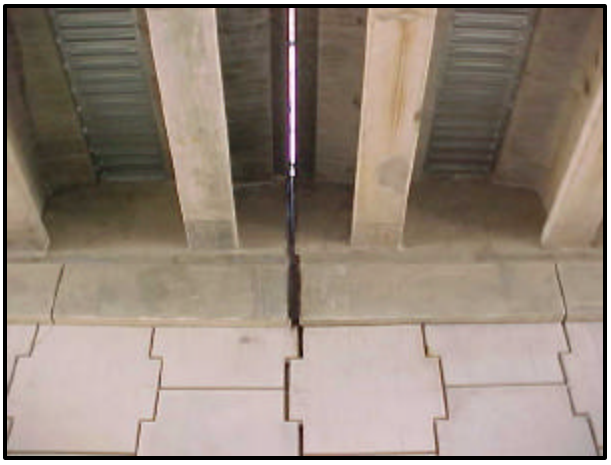
- Continuous Steel Tied Arch-Truss

- Contact

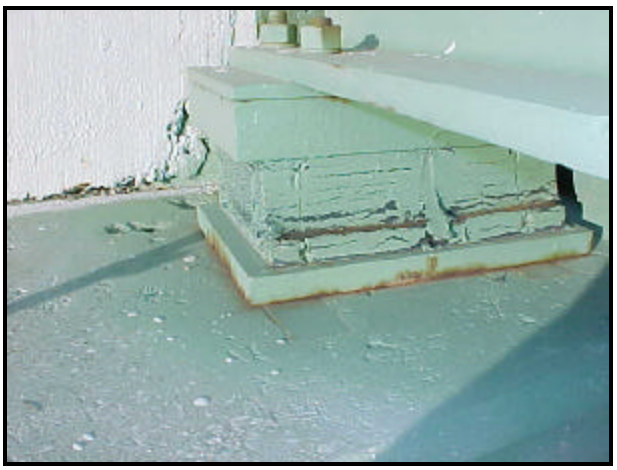
- Rocker Bearing

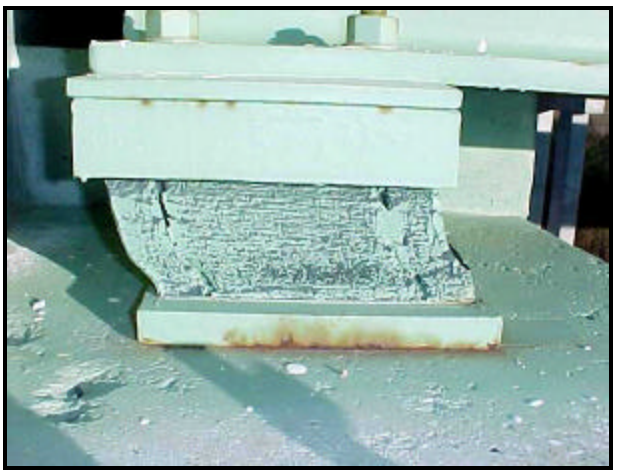
BEARINGS:

- Integral



- Elastomeric Bearing





PIPELINES:

RESTRAINER:

3. POSSIBLE TYPES OF BRIDGE AND ROADWAY DAMAGE

3.1. General

Highway bridges have a structural combination of superstructure, substructure and support bearings. Superstructure consists of all the structural parts of the bridges that make the horizontal span like slab, beams, girders or truss members. Substructures consist of structural parts of the bridges that provide the support to the horizontal span like abutments, piers and columns. Bearings are placed between the superstructure and substructure. Figure 3.1 shows all the key components of a typical highway bridge.

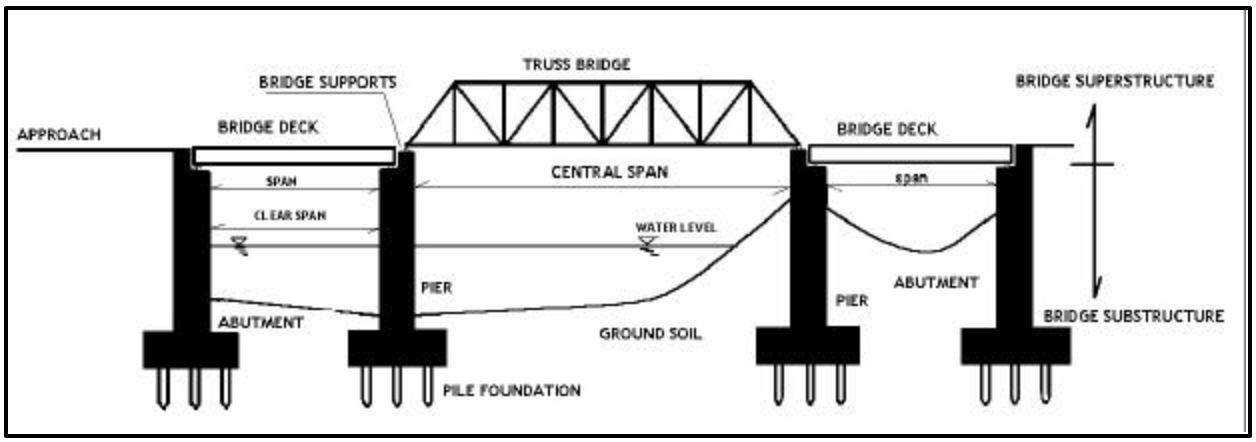


FIGURE 3.1 View of different structural parts of a typical highway bridge

3.2. Classification of Damage

The Level 1 Inspection can be summarized as follows:

- Green Tag - Safe for Traffic
- Yellow Tag - Require Level 2 Evaluation (or quickly repairable)
- Red Tag - Unsafe for traffic (must be closed)

More detailed damage classification tables are given in the Figure 3.2 by considering the different components of highway bridges.

	GREEN TAG	YELLOW TAG	RED TAG
Traffic Barriers and Railings	damage does not impede traffic	damage impedes traffic	
Movement at Expansion Joints	1) < 1in. offset in vertical or horizontal alignment 2) spalling of concrete cover	1) 1 to 6 in. offset in vertical or horizontal alignment 2) local buckling of steel stringers	> 6 in. offset in vertical or horizontal alignment
Seats at Expansion Joints	< 1 in. reduction in seat length	> 1in. reduction in seat length	unseating
Bearings		visible damage	

	GREEN TAG	YELLOW TAG	RED TAG
Columns, Cross-Beams and Piers	1) vertical cracks in RC beams. 2) horizontal cracks in RC columns and piers	1) diagonal cracks in RC beams, columns and piers. 2) loss of concrete cover 3) any crack in steel beams or columns	1) bar buckling in RC beams, columns and piers 2) local buckling in steel columns
Column/ Beam Joints		1) any cracks. 2) loss of concrete cover	
Footings/ Pile Caps	space between columns and surrounding earth	any other damage (e.g., cracks, spalling, rotation)	

	GREEN TAG	YELLOW TAG	RED TAG
Abutments	spalling at expansion joint	any other damage (e.g., cracks, spalling, rotation)	
Approach/ Abutment interface	< 1 in. settlement	1 to 6 in. settlement	> 6 in. settlement
Roadway	Normal Driving Conditions	Reduced Speed, or Quickly Repairable	Impassible

FIGURE 3.2. Damage classification tables for bridges

3.3. Level 1 Examples of Bridge and Roadway Damage

In this section examples of bridge damage are given. The classification follows the damage classification tables given in previous section. The damage examples are organized in the categories of:

- Bridge Collapse / Bridge Partial Collapse / Roadway Closed
- Superstructure Damage
- Substructure Damage
- Bearing Damage
- Soil Problems

Collapse / Partial Collapse / Roadway Closed

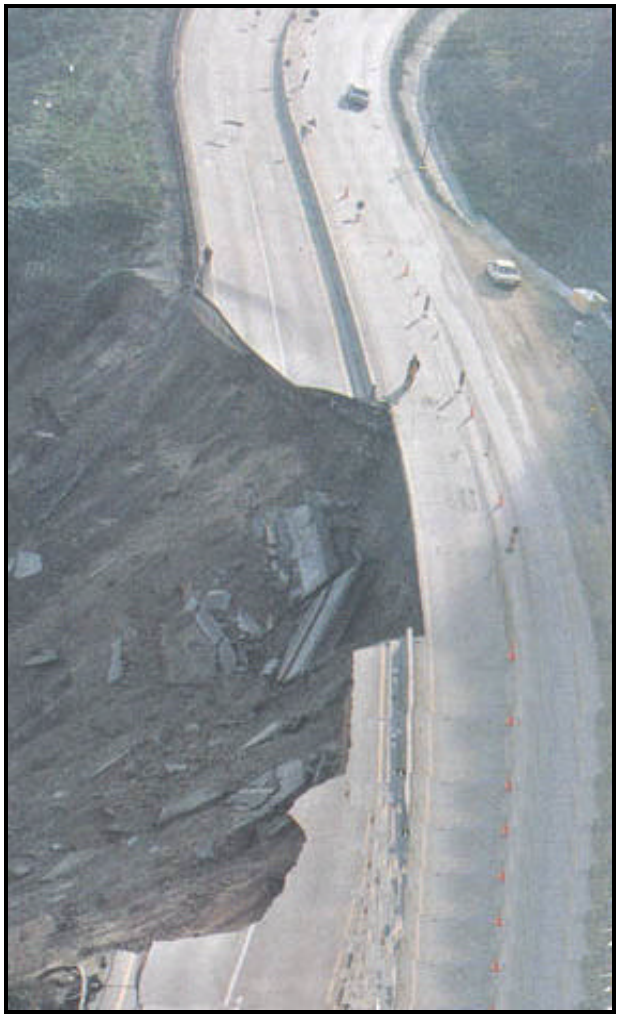


FIGURE 3.3 Collapse of roadway due to slope failure after Duzce EQ 1999 (10)

FIGURE 3.4 Collapse of roadway due to fault rupture after Izmit EQ 1999 (10)

FIGURE 3.7. Failure of a monolithic RC girder bridge after Loma Prieta EQ 1989 (11)

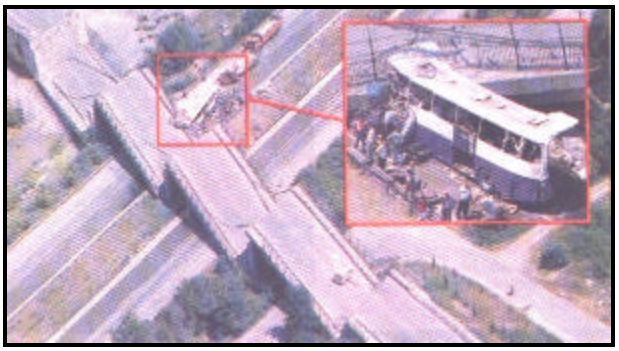


FIGURE 3.5 Failure of a prestressed concrete box beam bridge after Izmit EQ 1999 (10)

FIGURE 3.8 Collapse of RC girder bridge after Loma Prieta EQ 1989 (11)

FIGURE 3.6. Collapse of deck and piers after Taiwan Earthquake 1999 (15)

FIGURE 3.9 Collapse of bridge deck after Northridge 1994 (11)

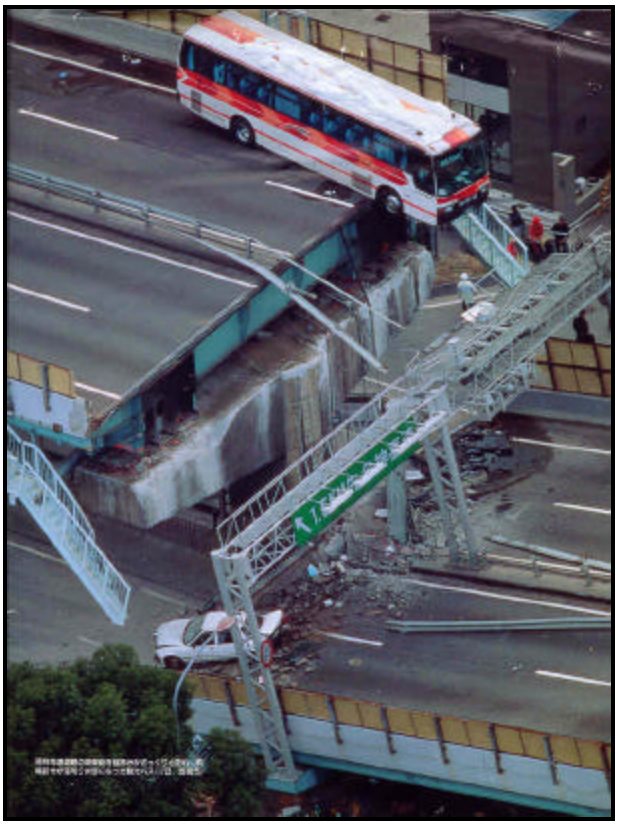


FIGURE 3.10 Collapse of steel deck bridge after Kobe 1995 Earthquake (12)

In the cases shown in the Figure 3.2 to 3.9, there is no chance to permit traffic flow, it's physically impossible. Highway must be closed immediately and barriers should be placed and crisis center should be informed. Walking on or passing under such kind of collapsed bridge can be dangerous. This situation is defined as Red Tag.

Superstructure Damage:

Superstructure damage can be classified as lateral, longitudinal or vertical movement, pounding, buckling, cracking, and failure. The examples shown in Figures 3.11-3.22 are red tagged bridges except for those shown in Figures 3.17 - 3.21 considered yellow tagged examples.

FIGURE 3.11 Excessive longitudinal movement of the bridge deck (15)

FIGURE 3.12 The excessive transversal movement of bridge after Izmit EQ (10)

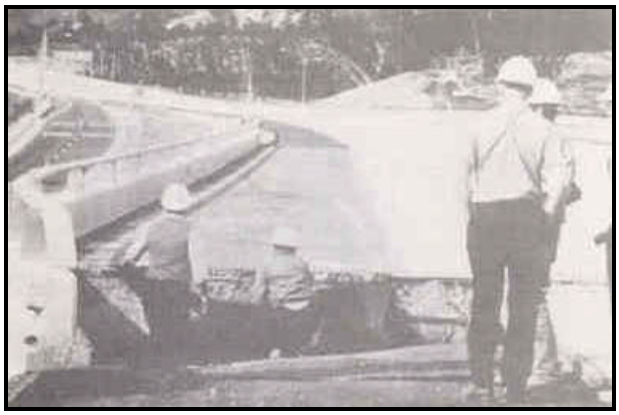


FIGURE 3.14 Excessive differential settlement of the backfill (1)

FIGURE 3.13 Excessive longitudinal movement of steel box girder bridge (11)

FIGURE 3.15 Lateral movement of prestressed RC box girders (10)

FIGURE 3.16 Longitudinal movement of RC box girders after Duzce EQ 1999 (10)

FIGURE 3.17 Vertical offset between decks after Northridge EQ 1994 (11)

FIGURE 3.19 The expansion of the joints Taiwan EQ 1999 (15)

FIGURE 3.18 Excessive movement of expansion joints after Taiwan EQ 1999 (15)

FIGURE 3.20 The expansion of the joints after Loma Prieta Earthquake 1989 (11)

FIGURE 3.21 Vertical and horizontal offset on a bridge after Northridge EQ. 1994 (11)

FIGURE 3.22 Settlement of Bridge (26)

Substructure Damage:

Substructure damage can be classified as local buckling, shear key damage, settlement, tilting, sliding, rotation, cracking, and failure. The following examples are red tagged bridges except those shown in Figures 3.30 and Figures 3.33- 3.35.

FIGURE 3.23 Column failure (11)

FIGURE 3.24 Failure of RC e column (11)

FIGURE 3.25 Failure of the bottom of the RC bridge column (11)

FIGURE 3.26 Failed RC bridge column (11)

FIGURE 3.28 Heavy damage in RC bridge piers after Kobe Earthquake 1995 (14)

FIGURE 3.29 Shear crack in bents after Northridge Earthquake 1994 (11)

FIGURE 3.27 View of damaged RC bridge pier after Kobe Earthquake 1995 (13)

FIGURE 3.30. Shear key failure of a bridge after Northridge Earthquake 1994 (11)

FIGURE 3.31 Buckling of steel girders (11)

FIGURE 3.34 Transversal movement of abutment (11)

FIGURE 3.32 Movement of an abutment after Northridge Earthquake 1994 (11)

FIGURE 3.35 Pounding damage at abutment (11)

FIGURE 3.33 Separation of abutment (11)

Bearing Damage:

Bearing damages consist of failure, movement of rocker/elastomeric bearings, shearing, pullout or bearing of bolts for contact type of bearings. The examples consist of red tagged bridges except for the case shown in Figure 3.40.

FIGURE 3.38 Failure of elastomeric bearing and cracking of girder beam (10)

FIGURE 3.36 Failure of two anchor bolts for a girder after Northridge EQ 1994 (11)

FIGURE 3.39 View of a failed elastomeric bearing pad after Izmit EQ 1999 (10)

FIGURE 3.37 Failure of an elastomeric bearing due to longitudinal movement of girder (10)

FIGURE 3.40 Spalling near location of anchor bolts after Northridge Earthquake 1994 (11)

Soil Problems:

Slope failures, soil liquefaction, soil fissures, differential settlements can be generalized as soil problems. The following examples can be considered as yellow tagged bridges.

FIGURE 3.41 Separation of soil at column base of a pier after Northridge EQ 1994 (11)

FIGURE 3.42 Separation of column from the surrounding soil after Northridge EQ1994 (11)

FIGURE 3.43 Disturbed soil at the base of column after Northridge EQ 1994 (11)

Secondary Structure Damage:

FIGURE 3.44 Barrier cracking after Northridge Earthquake 1994 (11)

FIGURE 3.45 Minor damage on the deck of a bridge after Northridge EQ 1994 (11)

FIGURE 3.48 Surface damage to highway pavement after Northridge EQ 1994 (11)

FIGURE 3.46 Curb separation after Northridge Earthquake 1994 (11)

FIGURE 3.49 Settlement damage on approaches after Northridge EQ 1994 (11)

FIGURE 3.47 Collapse of asphalt pavement due to washout after Northridge EQ 1994 (11)

3.4 Level 2 Behavior of Bridges under Earthquake Excitation

In this section, bridges that were Yellow tagged during the Level 1 inspection are further illustrated to establish whether they should be Red or Green tag. The damage as shown can be classified into:

- Roadway/Approach Damage
- Deck Damage
- Bearing Damage
- Superstructure Damage
- Substructure Damage
- Geotechnical Damage

Roadway/Approaches Damage:

FIGURE 3.50 The cracking of pavement due to pounding and settlement the bridge (15)

Deck Damage:

FIGURE 3.51 Transversal movement of bridge deck after Taiwan EQ (15)

FIGURE 3.52 View of RC bridge deck spalling after Taiwan EQ 1999 (11)

Bearing Damage:

FIGURE 3.53 Bearing movement and concrete spalling on the pier (11)

FIGURE 3.54 Tilted rocker bearings (9)

FIGURE 3.57 Elastomeric bearing movement and spalling of girder concrete (10)

FIGURE 3.55 Shift of bearings after collapse (11)

FIGURE 3.58 Sliding of elastomeric bearing (10)

FIGURE 3.56 Bearing movement (11)

FIGURE 3.59 Yield at pin support (in red color) (11)

FIGURE 3.60 Buckling of web near lower flange and crack in pedestal (11)

Superstructure Damage:

FIGURE 3.61 Local buckling of beam web near haunch (11)

FIGURE 3.62 Damage at the bottom of the RC collector beam (11)

FIGURE 3.63 Buckling in the girder due to pounding (11)

FIGURE 3.65 Heavy damage in RC box girder bridge (15)

FIGURE 3.64 Steel box girder movement and collapse of bearings (11)

FIGURE 3.66 Yielding at bolted connector beam (11)

FIGURE 3.67 Twisted steel braces (11)

FIGURE 3.70 Large cracks at abutment wing wall and slope (26)

FIGURE 3.68 Shear cracks at the RC bridge girder near support (26)

FIGURE 3.71 Separation of the RC superstructure and the abutment (11)

Substructure Damage:

FIGURE 3.69 Abutment slumping after Taiwan EQ 1999 (26)

FIGURE 3.72 Pounding of steel girder to the abutment (11)

FIGURE 3.73 Concrete spalling and cracking due to pounding of RC box girder after Izmit EQ 1999 (10)

FIGURE 3.75 Separation of the superstructure and the abutment (11)

FIGURE 3.74 Compression failure on the top of RC bridge pier after Taiwan EQ 1999 (15)

FIGURE 3.76 Heavily damaged RC bridge pier (15)

Geotechnical Damage:

FIGURE 3.77 Ground crack extending diagonally down slope under bridge (11)

FIGURE 3.78 Retaining wall failure after Taiwan EQ 1999 (26)

FIGURE 3.79 Settlement around RC bridge pier (11)

FIGURE 3.80 Spalling of concrete at the top of the pile for abutment after excavation (11)

FIGURE 3.81 Sand boils and ground cracks after Kobe EQ 1995 (11)

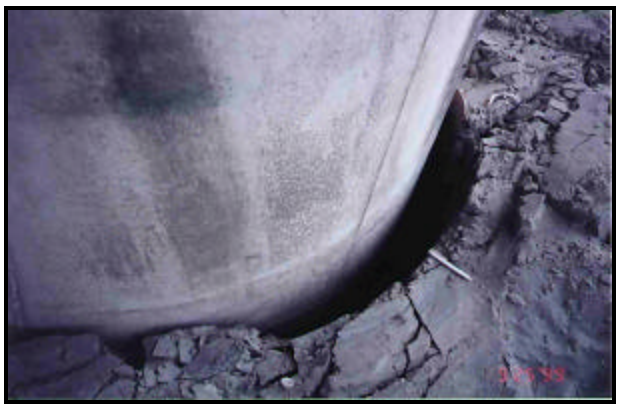


FIGURE 3.82 10 cm gap between ground and RC bridge pier (26)

FIGURE 3.83 Ejected sand and lateral spreading around RC bridge pier (11)

FIGURE 3.84 Soil failure due to the fault movement through RC bridge piers after Duzce EQ 1999 (10)

FIGURE 3.85 Buckled seismic restrainers (11)

4. POST-EARTHQUAKE SAFETY EVALUATION PRACTICE FOR HIGHWAY BRIDGES

4.1 Level 1 Inspection

The Rapid Assessment Bridge Inspection Form for the INDOT Level 1 teams is shown in Figure 4.1. This form is for multiple bridges, one bridge per line. Each line should be completed at the conclusion of the inspection of each bridge site. If a given bridge is in imminent danger of collapse, the inspection of the bridge shall follow the procedure outlined in this chapter. Assigned unit personnel (normally two people for each route) should pick up their inspection kit at their unit and inspect their pre-assigned primary route reporting back the condition of the roadway and all bridges on that route. Primary routes are the road sections needed for access to critical areas such as cities, hospitals, power stations, communication centers, schools, industries, neighboring states. After primary routes are inspected, the supervisor should determine the secondary routes to be inspected.

The Level 1 Inspection will consist of visual assessment of all bridges on the route. The main goal for this inspection is to be able to make a quick and accurate conclusion about the post earthquake situation of the bridges on the assigned route. The only time the inspectors can interrupt their inspection is when they encounter a life or death situation. It is critical that the inspection get done so outside help can be requested and routed via open roads. As indicated by the result of the inspection, traffic flow on the bridge should be either controlled or restricted or unrestricted. The results of the inspection will be utilized to develop the inspection schedule of the Level 2 teams. For each bridge that will be examined, the teams should complete the information in a given row, after checking all bridge elements. Finally, they should indicate their decision on the last three columns. If any suspicious situation exists or more detailed information is collected, team members can use the back page of the forms to make detailed explanations. Any major bridge and roadway closure should be reported to the Unit/ Subdistrict/ District immediately. In the previous chapter, common types of damage in bridges similar to those in Indiana were noted. It is recommended to complete a quick walk around the bridge then follow

with a more focused inspection keeping in mind the examples of damage as related to the type bridge surveyed. A suggested general procedure for the Level 1 inspection can be summarized as follows:

1. Begin the inspection of the assigned bridges on the previously determined route after collecting the necessary tools for the inspection (See section 4.3 for information on suggested equipments)
2. Minor roadway deficiencies should be recorded in the form including pavement damage, earth embankment failure, road obstructions and failure of the traffic control devices. Unit/ Subdistrict/ District should be informed immediately of any road or bridge damage that requires the closing of the roadway to traffic.
3. Complete Level 1 Inspection Form. The form is shown in Figure 4.1. It contains columns and rows. Complete one row per bridge inspected. The suggested step-by-step procedure is listed below.
4. Upon arrival to the bridge site, review and verify the bridge number.
5. Record the arrival time.
6. Check the traffic flow on the bridge. Although there may be traffic using the bridge that does not indicate the bridge is safe. Inspect all bridges assuming they may be damaged.
7. Approach bridge with caution and never walk immediately upon arrival directly under or over the bridge. Do not cross the bridge without first sighting down the curb/rail line and checking the underside for structural damage.
8. Prepare an inspection routine of the different components. Assign inspection tasks. Begin by inspecting approaches and continue in the order listed in the inspection form (see Figure 4.2). Upon starting sub-structure inspection each inspector should go down a different side of the bridge to provide safety by separation and to speed the inspection.
9. Discuss observation with the other members of the team and make the evaluation of the condition.
10. After completing items 1 through 6 in the form with the comments YES, NO, or DRN (Detailed Review Needed), the team should come to an agreement regarding the condition of the bridge and enter in one of the last three columns of the form as appropriate. If a bridge received at least one YES for the damage types 1 through 5, either a RED tag for

closure, or if a more detailed inspection is needed (Level 2) a YELLOW tag should be entered. In case of no damage, a GREEN tag should be entered.

11. Additional recommendations and observations about the bridge and roadway can be written in the box provided at the bottom of the form.
12. If the bridge is given a RED tag requiring barricades, the Unit, Subdistrict, and District should be informed immediately and the disaster closure procedure outlined in Section 6.4 of the field guide should be followed. If the bridge can be traversed, but repairs are needed, place a YELLOW ribbon, if it is undamaged use a GREEN ribbon. Attach ribbons to the bridge signpost and write time/date/inspector initials.
13. Record time on the form indicating the end of the inspection of the assigned bridges in the space provided at the top of the form.

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:____of _____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	**1. Collapse / Partial Collapse/ Roadway Closed**	**2. Superstructure Damage** Movement, Pounding, Buckling, Cracking, Failure	**3. Substructure Damage** Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	**4. Bearing Damage** Failure, Movement, Shearing or pullout of bolts	**5. Soil Problems** Slope Failure, Soil Liquefaction, Fissure, Differential Settlement	**6. Secondary Structure Damage** Wing walls, Parapets, Pylons	**7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)**	**RED TAG**	**YELLOW TAG**	**GREEN TAG**
	YES NO DRN	**YES NO DRN**	**YES NO DRN**	**YES NO DRN**	**YES NO DRN**	**YES NO DRN**				

Roadway Problems Encountered and Comments:

Name of the Inspector(s)

FIGURE 4.1 Level 1 inspection form

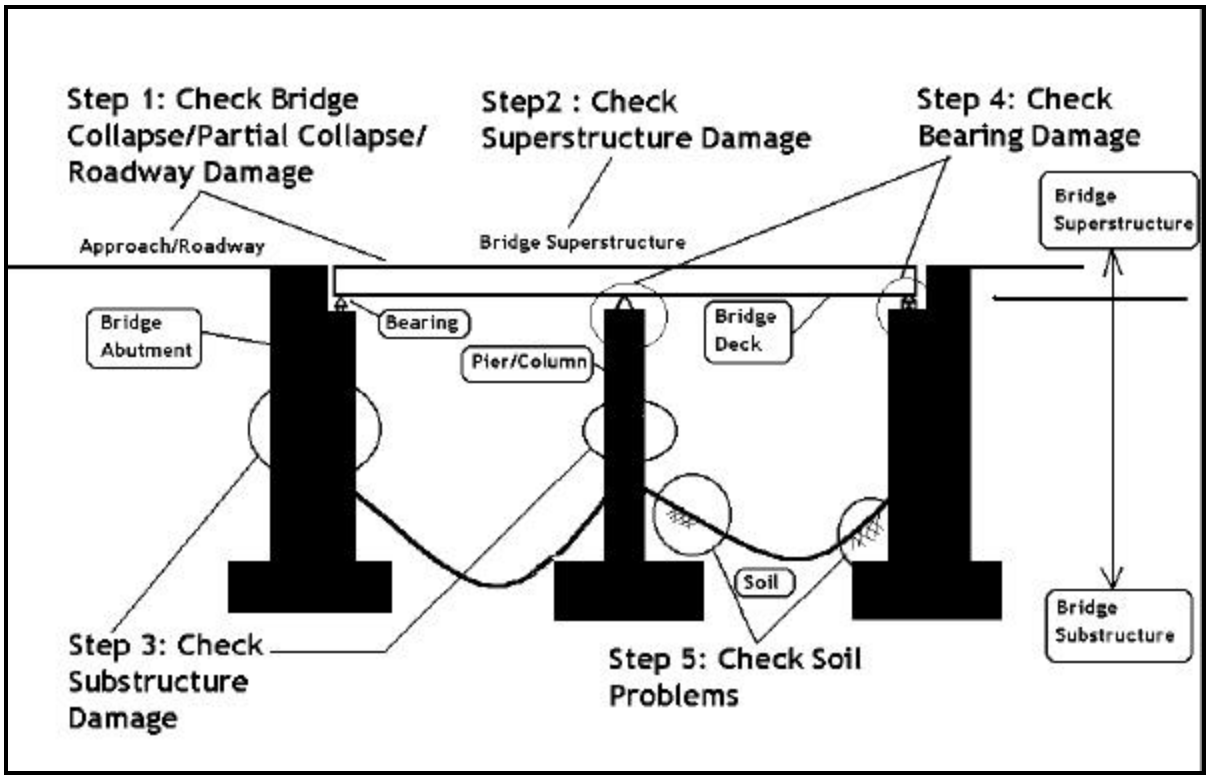


FIGURE 4.2 Level 1 inspection scheme

4.2. Level 2 Inspection

The bridge inspection form for the INDOT Level 2 teams is shown in Figure 4.3. A separate form should be completed for each bridge inspected. The bridge classification should be clearly indicated at the bottom of the form. Team members can use the back of the page to indicate additional comments. The main goal of the Level 2 inspection is to decide the final situation of the bridges yellow tagged during the Level 1 inspection. After completing the inspection of Yellow tagged bridges, teams re-inspect the Red tagged bridges if in-house repairs can be made. The Level 2 inspection teams consist of two trained and experienced people such as INDOT Construction and Design Project engineers or Project Supervisors. At no time, the two Level 2 inspectors should not go under the bridge at the same time. Because they have to backup each other and aftershocks may occur. It is important to note that the condition of damaged structures

may worsen due to the additional earthquakes, traffic or simply gravity. When assessing the bridges, one should assume that additional earthquakes would occur and consider what effect(s) may have. Sometimes it may be necessary to establish a monitoring plan to detect any changes in the condition of the damaged structures.

General procedure for the Level 2 inspection can be summarized as follows:

1. Start the inspection of the assigned bridge after collecting the necessary tools for the inspection.
2. Record the arrival and departure times. Complete the necessary information about the bridge, route and date/time. Note the difference between inspection day/time and the day/time of the main shock.
3. Examine the data from Level 1 inspection report for the bridge.
4. Check the traffic flow through the bridge. This may help to reach a conclusion about the condition of the bridge.
5. Prepare inspection plan for the different bridge components and prepare assignments for the inspection.
6. Inspect the superstructure and substructure following the sequence given in the Level 2 form.
7. Note the observed damage by checking the necessary boxes. Fill out the form shown in Figure 4.3. It contains 6 main damage type definitions for the different elements of the bridge structures and comments and section to make specific recommendations. One form must be used for each bridge inspected.
8. Discuss the observations with the members of the team and come to an agreement on the condition.
9. The final rating should be written on the bottom of the form.
10. If the conclusion is that the bridge/road must be closed, or barricades are required, contact the Unit, Subdistrict and District immediately.
11. Note any additional recommendations and conclusions in the box. The backside of the form can be used for additional explanations or sketches.

12. Place appropriate marked ribbon on the bridge sign to inform later inspectors about its condition.

Examples of the damage observed during previous earthquakes are summarized in Chapter 5. During the inspection of the various types of bridge components, care must be taken to make the correct assessment. All the structural elements, connections, supports, bearing elements and soil conditions should be checked.

For the concrete elements, flexural and shear cracks should be examined carefully. It should be considered that spalling of concrete and the exposure of reinforcing bars to open air may complicate the assessment damage resulting from the earthquake. Observed cracks have to be marked with paint and crack path and location should be recorded on a sketch with the note of crack width.

It is important to note that some reinforced concrete elements such as box girders, footings, and piles cannot be readily inspected. If damage of these elements is suspected, access must be gained to inspect them. For example, excavating the soil around the footings, checking pile caps may give better idea for the damage. For the box girder type of elements, opening holes on the cells and confined space entry may be necessary.

For the steel components, inspection of the damage is often not readily apparent such as in the concrete elements. All assemblies, plates, anchor bolts, restrainers, connections, hangers, welds and other details should be carefully inspected. Sheared bolts, buckled or bent members, cracked welds, shifted girders, anything out of order should be noted. For the composite elements, anchor bolts to connect the steel parts to the concrete elements should be checked such as in steel columns connected to abutments and pier caps.

INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route:	Date and Local Time:
Bridge ID:	Bridge Location :

DAMAGE OBSERVED:

1. ROADWAY/APPROACHES

- ☐ Not Operational
- ☐ Roadway Settlement
- ☐ Off Bridge Seat
- ☐ Excessive Transversal Movement
- ☐ No Damage
- ☐ Other (explain)

2. DECK

- ☐ Longitudinal Joints Enlarged
- ☐ Expansion Joints Enlarged
- ☐ Wearing Surface Cracking
- ☐ Wearing Surface Spalling
- ☐ Deck Cracking/Spalling
- ☐ Misalignment of Guard Rails, Curbs, Pavement Lines
- ☐ No Damage

3. BEARINGS

- ☐ Failure of Bearings (Integral, Contact, Rocker, Elastomeric)
- ☐ Movement of Bearings
- ☐ Shearing or Pullout of Bolts
- ☐ No Damage

4. SUPERSTRUCTURE

Reinforced Concrete Slab
☐ Flexural Cracks ☐ Shear Cracks
☐ Connection Failure ☐ No Damage ☐ N/A

Culverts
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Connection Failure
☐ Metal Pipes Distortion & Deflection ☐ No Damage ☐ N/A

Steel Truss Members, Floor Beams, Stringers
☐ Local Buckling ☐ Upper Chord ☐ Lower Chord ☐ Diagonals
☐ Connection Failure ☐ No Damage ☐ N/A

Concrete Arches
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure
☐ Spandrel Wall Cracking/Collapse ☐ No Damage ☐ N/A

Steel/Concrete Girders, Beams
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure ☐ Local Buckling
☐ No Damage ☐ N/A

5. SUBSTRUCTURE

Abutments
☐ Wall Movement/Rotation ☐ Pounding Damage ☐ Wing wall Movement
☐ Wing wall Separation ☐ Backfill Settlement ☐ Foundation Movement
☐ Abutment Pile Damage ☐ Cracking on the Walls ☐ No Damage ☐ N/A

Piers
☐ Joint Failure ☐ Moment Failure ☐ Shear Failure ☐ Inadequate Splice Failure
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Foundation Failure
☐ No Damage ☐ N/A

6. GEOTECHNICAL

- ☐ Slope Failure
- ☐ Settlement
- ☐ Soil Liquefaction
- ☐ Fault Movement
- ☐ Other
- ☐ No Damage
- ☐ N/A

COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
   - 3a. In-House Repair Possible
   - 3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:
SAFE (Green Tag):_____MORE REVIEW NEEDED (Yellow Tag) _____UNSAFE(Red Tag):_____
Name of the Inspector(s):

FIGURE 4.3 Level 2 inspection form

4.3. Suggested tools for the evaluation procedure

4.3.1. Suggested tools to perform Level 1 inspection

- Radio and cellular phone for communications
- Inspection procedures field guide
- Primary and county route maps, state maps
- List of bridges on the routes
- Clipboard, pen, pencil
- Waterproof marker
- Ribbons in three colors: Red ribbon to close, Yellow ribbon to identify open but repairs or additional inspection needed and Green ribbon to denote undamaged with color wording on ribbon
- Rope
- Safety vest
- Hardhat
- Flash light
- "Road Closed" signs, flashers and stands. (See section 4.4)
- Shovel
- Barrels
- Cones
- Traffic control paddles
- First aid kit
- Camera and film
- Fire extinguisher
- 100 ft tape
- Hammer
- Extra flashlight batteries
- Binoculars
- Chain saw

4.3.2 Suggested tools to perform a detailed evaluation for Level 2

The necessary resources for the Level 2 teams are:

- Level 1 inspection form data
- Bridge inventory book
- Primary and county route maps
- Radio and/or satellite phone for communications
- Water, food, clothes, blankets, tents, shelter and supplies for at least 3 days per person
- Inspection Form for each bridge, field book, sketchpad, paper, pencils, clipboard.
- 100-foot tape, pocket tape, and ruler.
- Testing hammer or geologist hammer
- Inspection mirror and flashlight for inaccessible areas
- Keel marker
- Camera and film
- Binoculars
- Tool belt, boots
- Wire brush, shovel, whisk broom
- Pocket knife
- Safety harness and lanyard
- Scraping toll
- Calipers
- Ladders
- Lead lines
- Hand level
- Thermometer
- Pocket or wrist watch
- Plumb bob
- Safety vest
- Hard hat
- Rope

- Axe
- Tape recorder and tape
- Tool box
- Life jacket
- Gloves, PVC coated and leather
- Ear plugs
- Eye wash
- First aid kit
- Cones, traffic safety
- Fire extinguisher
- Sign, flagman's signal

For detailed inspection, following items may be required for the different type of bridges:

- Crack gage or comparator to measure the width of the cracks
- Piano wire or some other device for measuring the depth of cracks
- Screwdriver
- Pliers
- Wrench
- Magnifying glass
- Periscope, fluorescent tube light
- Hand drill, borer or ship auger
- Straight edge
- Flagging for marking damaged areas

4.4. Bridge Closing Procedure

INDOT has a formal procedure for the planned closing of a road or bridge that includes pre-closure notification to the public (through the media and signs), marking a detour/approach and signing the actual barricade closure. In a major disaster INDOT has a responsibility to take all reasonable actions to notify and protect the public as soon as the need for a road closure is known (see Appendix A, Indot Response Procedure for Major Disasters).

Each unit shall maintain a minimum of one set of "Road Closure" signs (Figure 4.4) with type B flashers and sign supports for each primary disaster route in their unit. Level 1 inspectors shall load one road closure setup (2 signs) onto their truck prior to starting their inspection. If there is a need for closure during inspection, the signs will be put up on each approach and unit/subdistrict/ district immediately notified so that the approach signing, barricading and a detour can be placed in a timely manner by follow up personnel. Once this is done, Level 1 inspectors shall continue the inspection on their primary route using the state and county maps to find a way around the closure. If additional closures are encountered that information is to be relayed back to the unit/subdistrict for assistance. One inspector may have to remain at the closure until relieved if no signing or other traffic control is available (try to use local law enforcement if available

FIGURE 4.4 Road closure sign

5. EVALUATION EXAMPLES

5.1 Level 1 Examples

5.1.1 Example 1

In this section of the field guide, the Level 1 Bridge Inspection Form is completed based on a series of examples of damaged bridges. In the first example, the highway bridge, Santa Clara River Bridge (Interstate 5, 53-0687, CA) damaged after 1994 Northridge Earthquake, is evaluated (11). The available photos are arranged in the order of a typical inspection routine as described in the Level 1 form.

FIGURE 5.1 View of bridge superstructure after the earthquake (11)

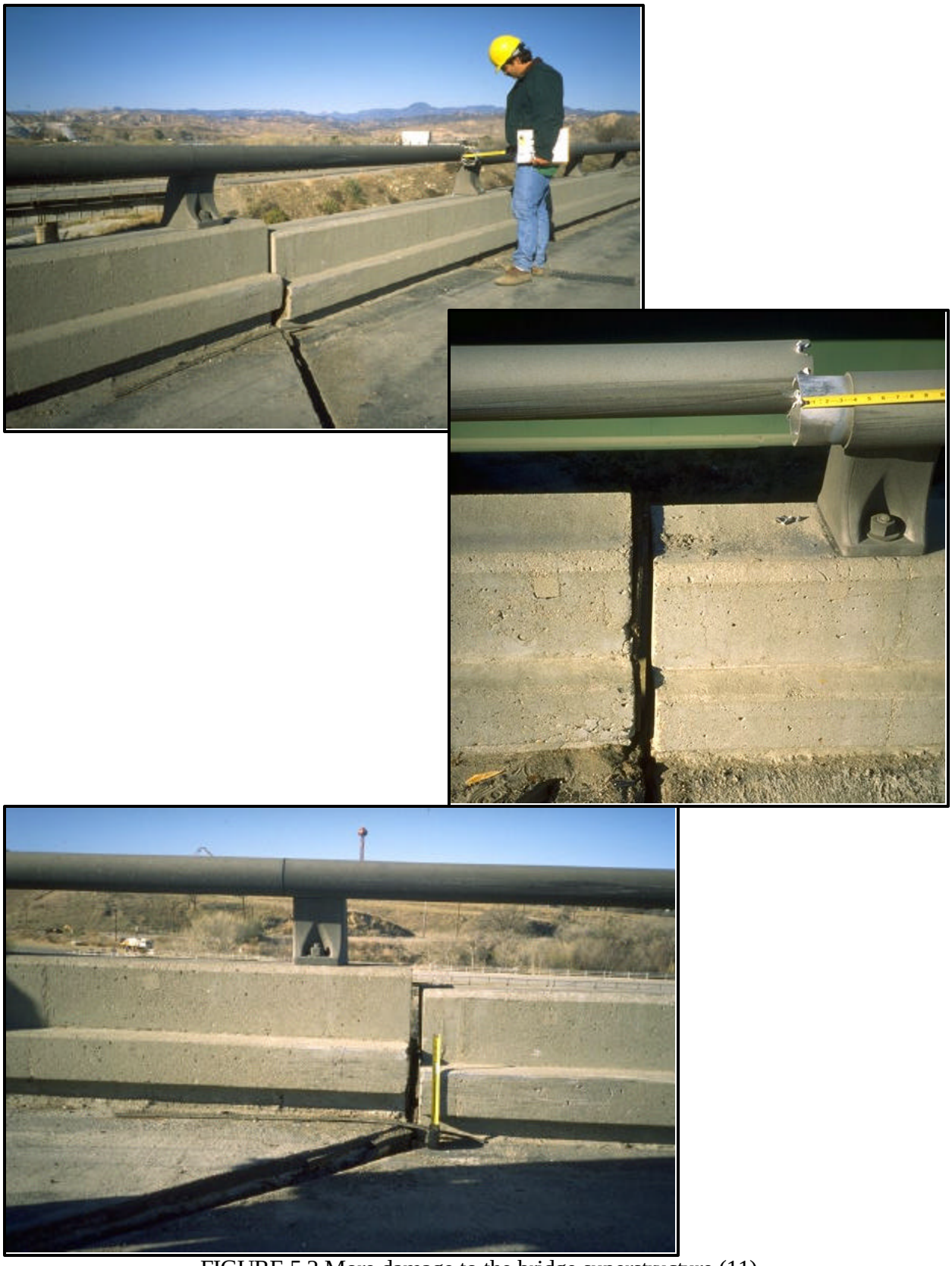


FIGURE 5.2 More damage to the bridge superstructure (11)

FIGURE 5.3 Different views of bridge superstructure (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:___of ____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
Bridge No.1	NO	YES								

FIGURE 5.4 The Level 1 form, Bridge Example 1, Steps 1 and 2

FIGURE 5.5 Damage to one of the bridge piers (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:____of _____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
Bridge No.1	NO	YES	YES							

FIGURE 5.6 The Level 1 Form, Bridge Example 1, Step 3

FIGURE 5.7 Damage to the bridge bearings (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:___of _____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
Bridge No.1	NO	YES	YES	YES						

FIGURE 5.8 The level 1 Form, Bridge Example 1, Step 4

FIGURE 5.9 View of substructure and soil of the bridge (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:___of ____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
Bridge No.1	NO	YES	YES	YES	NO	YES		X		

FIGURE 5.10 Completed Level 1 Inspection Form for Example Bridge 1

5.1.2 Example 2

The second example is the Parkfield Highway Bridge (Bridge #1309, Parkfield, CA). The bridge was damaged after Parkfield, California Earthquake, June 27-29, 1966. The available pictures are arranged in the order of a typical inspection routine as described in the Level 1 form.

FIGURE 5.11 View of the Parkfield Highway Bridge after the earthquake (11)

FIGURE 5.12 View of the damaged bridge components (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page: 1 of 1

Date and Local Time: March 7, 2000 9:45 am Parkfield Highway

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
Br. #1309	No	No	Yes	No	No	No			X	

FIGURE 5.13 Completed Level 1 form for Example Bridge 2

5.1.3. Example 3

The Interchange Bridge between I-5 and I-210 (California), was damaged after San Fernando EQ, 1971. The available pictures are arranged in the order of a typical inspection routine as described in the Level 1 form. At the end, particular row in the Level 1 Inspection Form is completed according to the damage scenes of the bridge.

FIGURE 5.14 Superstructure damage of the third example bridge after earthquake (11)

FIGURE 5.15 Substructure damage of the bridge (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:____of _____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	**1. Collapse / Partial Collapse/ Roadway Closed**	**2. Superstructure Damage** Movement, Pounding, Buckling, Cracking, Failure	**3. Substructure Damage** Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	**4. Bearing Damage** Failure, Movement, Shearing or pullout of bolts	**5. Soil Problems** Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	**6. Secondary Structure Damage** Wingwalls, Parapets, Pylons	**7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)**	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
Int.I5-I210	Yes	No	Yes	No	No	No		X		

FIGURE 5.16 Completed Level 1 Inspection form for bridge example 3

5.2 Level 2

5.2.1 Example 1

In this section of the field guide, Level 2 Bridge Inspection Form is completed by using a series of examples of damaged bridge photos. As a first example the highway bridge, I5-14 Interchange, CA is chosen. The bridge was damaged after the Northridge Earthquake, 1994 (11). (Figures 5.17-5.18). The available pictures are arranged in the order suggested for a typical Level 2 inspection. The bridge is assumed as yellow tagged after inspection by Level 1 Inspection team, the Level 1 form is shown in Figure 5.19. The completed Level 2 Inspection form is shown following the example illustrations.

FIGURE 5.17 Different views from the superstructure of the bridge (11)

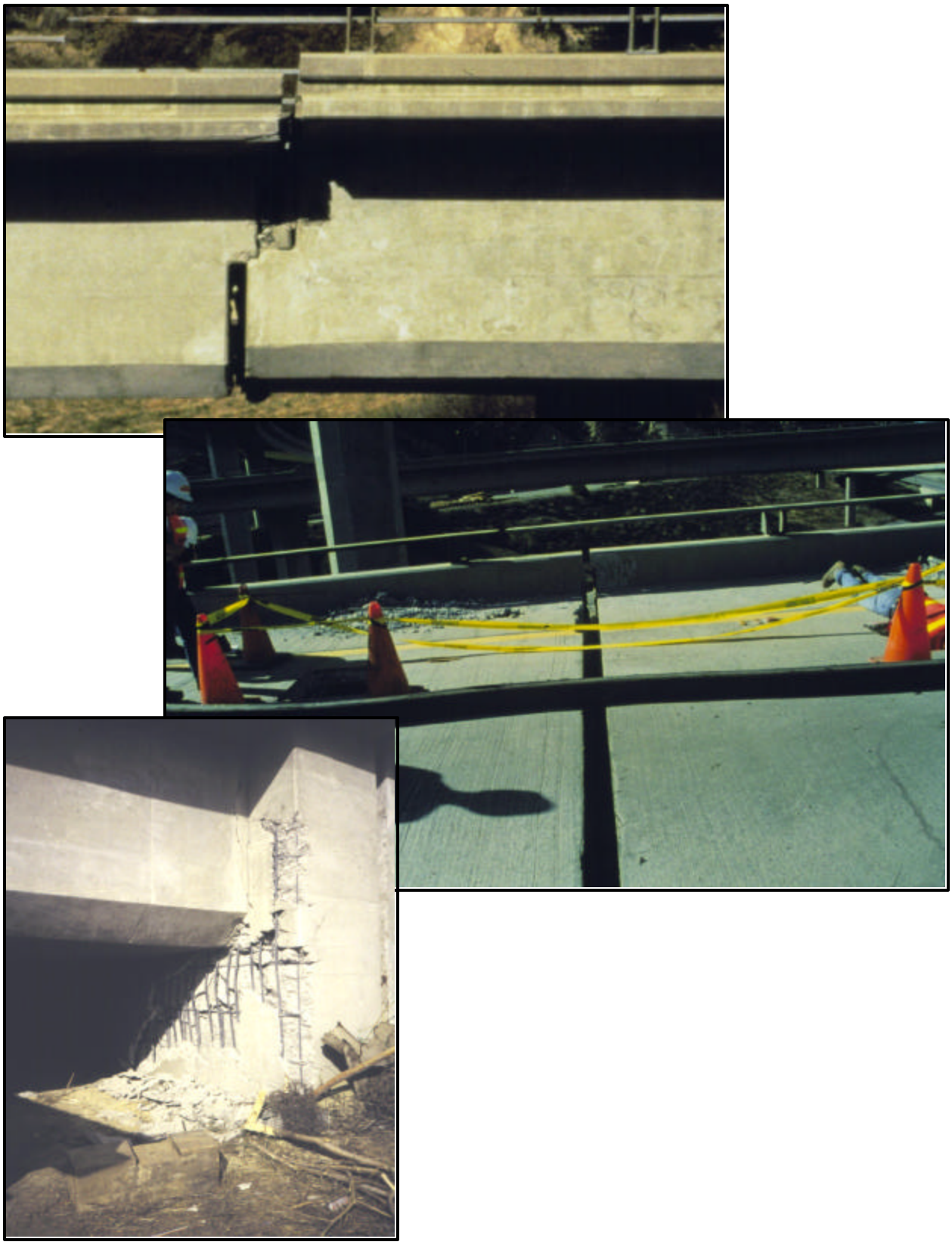


FIGURE 5.18 Different views of damage from the damaged bridge (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

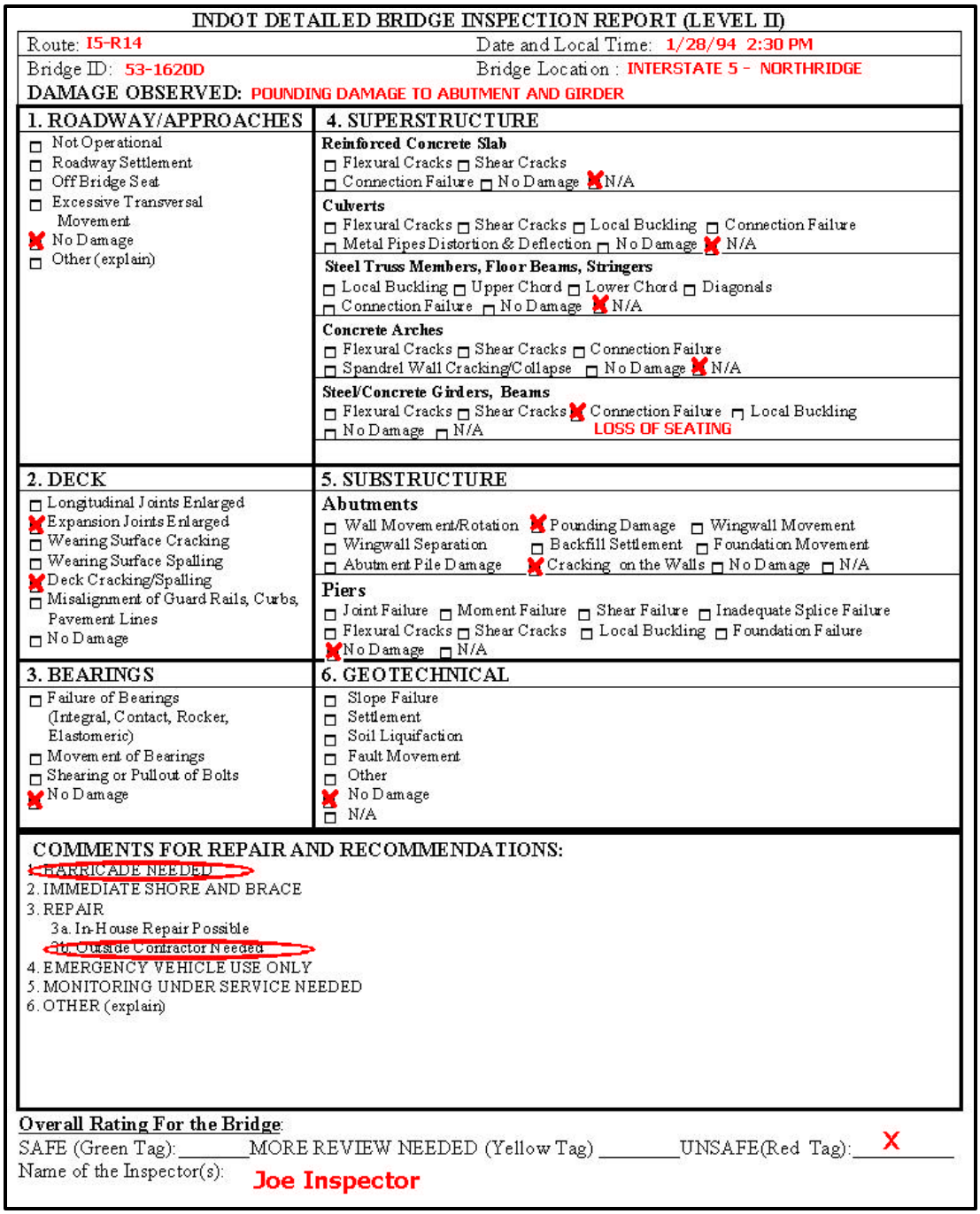
Route__I5__ Direction_____from Intersection_____ Page:_1_of _1__

Date and Local Time: 1/28/94 8:20 am Interstate 5-Northridge

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
53-1620D	No	Yes	Yes	No	No	Yes			X	
53-1626	No	No	Yes	No	Yes	No			X	

FIGURE 5.19 Completed Level 1 form for the example bridge (53-1620D)



INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R14 — Date and Local Time: 1/28/94 2:30 PM

Bridge ID: 53-1620D — Bridge Location : INTERSTATE 5 - NORTHRIDGE

DAMAGE OBSERVED: POUNDING DAMAGE TO ABUTMENT AND GIRDER

1. ROADWAY/APPROACHES

- ☐ Not Operational
- ☐ Roadway Settlement
- ☐ Off Bridge Seat
- ☐ Excessive Transversal Movement
- ☒ No Damage
- ☐ Other (explain)

2. DECK

- ☐ Longitudinal Joints Enlarged
- ☒ Expansion Joints Enlarged
- ☐ Wearing Surface Cracking
- ☐ Wearing Surface Spalling
- ☒ Deck Cracking/Spalling
- ☐ Misalignment of Guard Rails, Curbs, Pavement Lines
- ☐ No Damage

3. BEARINGS

- ☐ Failure of Bearings (Integral, Contact, Rocker, Elastomeric)
- ☐ Movement of Bearings
- ☐ Shearing or Pullout of Bolts
- ☒ No Damage

4. SUPERSTRUCTURE

Reinforced Concrete Slab
☐ Flexural Cracks ☐ Shear Cracks
☐ Connection Failure ☐ No Damage ☒ N/A

Culverts
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Connection Failure
☐ Metal Pipes Distortion & Deflection ☐ No Damage ☒ N/A

Steel Truss Members, Floor Beams, Stringers
☐ Local Buckling ☐ Upper Chord ☐ Lower Chord ☐ Diagonals
☐ Connection Failure ☐ No Damage ☒ N/A

Concrete Arches
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure
☐ Spandrel Wall Cracking/Collapse ☐ No Damage ☒ N/A

Steel/Concrete Girders, Beams
☐ Flexural Cracks ☐ Shear Cracks ☒ Connection Failure ☐ Local Buckling
☐ No Damage ☐ N/A
LOSS OF SEATING

5. SUBSTRUCTURE

Abutments
☐ Wall Movement/Rotation ☒ Pounding Damage ☐ Wingwall Movement
☐ Wingwall Separation ☐ Backfill Settlement ☐ Foundation Movement
☐ Abutment Pile Damage ☒ Cracking on the Walls ☐ No Damage ☐ N/A

Piers
☐ Joint Failure ☐ Moment Failure ☐ Shear Failure ☐ Inadequate Splice Failure
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Foundation Failure
☒ No Damage ☐ N/A

6. GEOTECHNICAL

- ☐ Slope Failure
- ☐ Settlement
- ☐ Soil Liquifaction
- ☐ Fault Movement
- ☐ Other
- ☒ No Damage
- ☐ N/A

COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
   3a. In-House Repair Possible
   3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:

SAFE (Green Tag):_____ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE(Red Tag): X

Name of the Inspector(s): Joe Inspector

FIGURE 5.20 Completed Level 2 Inspection Form, Bridge Example 1 (53-1620D)

5.2.2 Example 2

The I5-R216 Interchange Bridge (53-1626,CA) was damaged after the Northridge Earthquake, 1994 (11) (Figures 5.21- 5.24). The completed forms (Level 1 and 2) are shown following the example photos those are arranged in order of a typical Level 2 inspection (Figures 5.25-26).

FIGURE 5.21 Different views of the superstructure of the second example bridge (11)

FIGURE 5.22 Different views of the superstructure of the bridge (11)

FIGURE 5.23 Different views of the superstructure of the bridge (11)

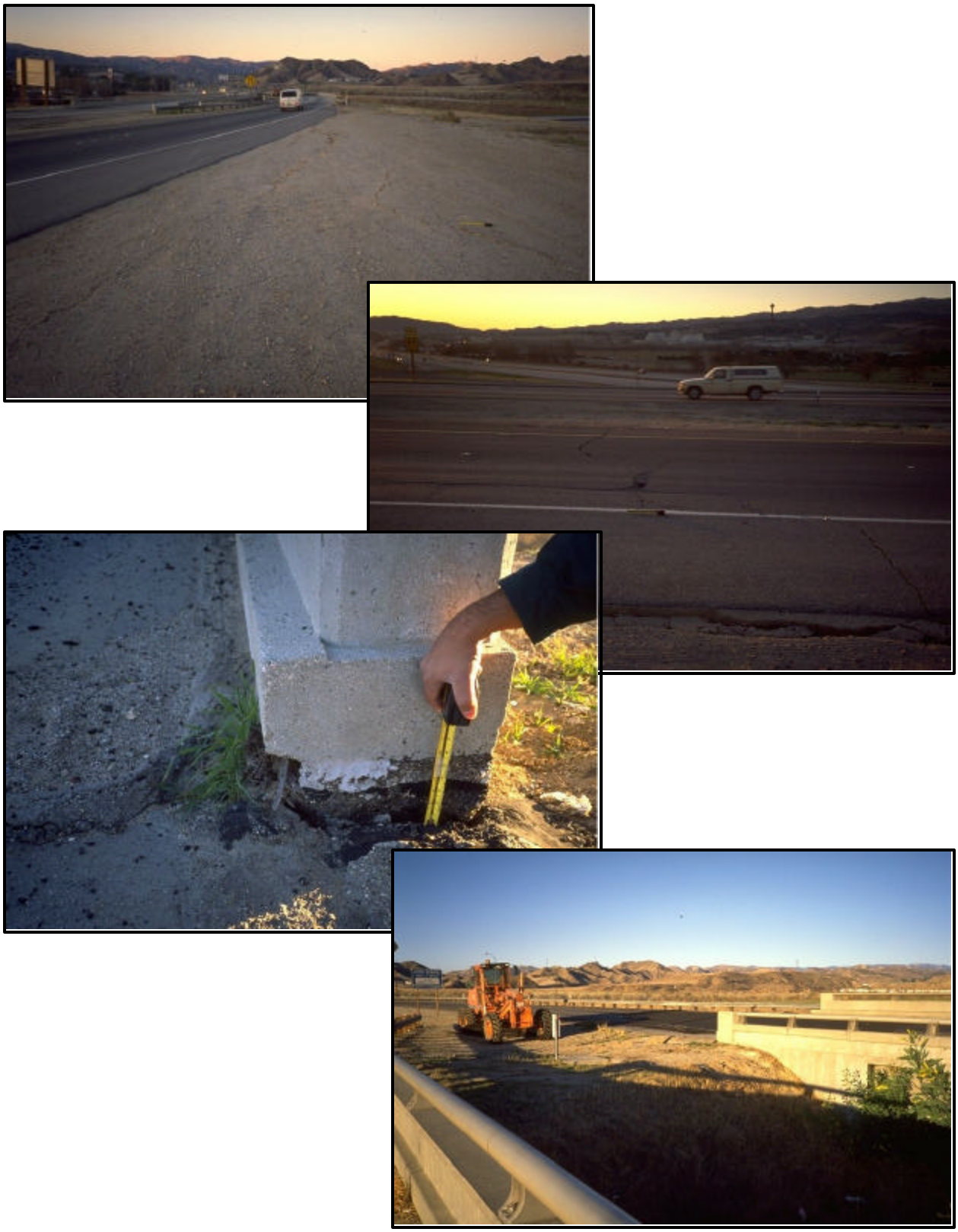


FIGURE 5.24 Different views of the second example bridge (11)

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route__I5__ Direction_____from Intersection_____ Page:_1_of _1__

Date and Local Time: 1/28/94 8:20 am Interstate 5-Northridge

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	1. Collapse / Partial Collapse/ Roadway Closed	2. Superstructure Damage Movement, Pounding, Buckling, Cracking, Failure	3. Substructure Damage Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	4. Bearing Damage Failure, Movement, Shearing or pullout of bolts	5. Soil Problems Slope Failure, Soil Liquifaction, Fissure, Differential Settlement	6. Secondary Structure Damage Wingwalls, Parapets, Pylons	7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)	RED TAG	YELLOW TAG	GREEN TAG
	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN	YES NO DRN				
53-1620D	No	Yes	Yes	No	No	Yes			X	
53-1626	No	No	Yes	No	Yes	No			X	

FIGURE 5.25 Completed Level 2 Inspection Form, Bridge Example 2

INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R126 — Date and Local Time: 1/28/94 4:30 PM

Bridge ID: 53-1626 — Bridge Location : INTERSTATE 5 - NORTHRIDGE

DAMAGE OBSERVED: SPALLING OF COLUMNS

1. ROADWAY/APPROACHES

- ☐ Not Operational
- ☐ Roadway Settlement
- ☐ Off Bridge Seat
- ☐ Excessive Transversal Movement
- ☐ No Damage
- ☒ Other (explain)

EMBANKMENT CRACKS
ROADWAY CRACKING

2. DECK

- ☐ Longitudinal Joints Enlarged
- ☐ Expansion Joints Enlarged
- ☐ Wearing Surface Cracking
- ☐ Wearing Surface Spalling
- ☐ Deck Cracking/Spalling
- ☐ Misalignment of Guard Rails, Curbs, Pavement Lines
- ☒ No Damage

3. BEARINGS

- ☐ Failure of Bearings (Integral, Contact, Rocker, Elastomeric)
- ☐ Movement of Bearings
- ☐ Shearing or Pullout of Bolts
- ☒ No Damage

4. SUPERSTRUCTURE

Reinforced Concrete Slab
☐ Flexural Cracks ☐ Shear Cracks
☐ Connection Failure ☐ No Damage ☒ N/A

Culverts
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Connection Failure
☐ Metal Pipes Distortion & Deflection ☐ No Damage ☒ N/A

Steel Truss Members, Floor Beams, Stringers
☐ Local Buckling ☐ Upper Chord ☐ Lower Chord ☐ Diagonals
☐ Connection Failure ☐ No Damage ☒ N/A

Concrete Arches
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure
☐ Spandrel Wall Cracking/Collapse ☐ No Damage ☒ N/A

Steel/Concrete Girders, Beams
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure ☐ Local Buckling
☒ No Damage ☐ N/A

5. SUBSTRUCTURE

Abutments
☒ Wall Movement/Rotation ☐ Pounding Damage ☐ Wingwall Movement
☐ Wingwall Separation ☒ Backfill Settlement ☒ Foundation Movement
☐ Abutment Pile Damage ☐ Cracking on the Walls ☐ No Damage ☐ N/A

Piers
☐ Joint Failure ☐ Moment Failure ☐ Shear Failure ☐ Inadequate Splice Failure
☒ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Foundation Failure
☐ No Damage ☐ N/A HINGE SPALLING

6. GEOTECHNICAL

- ☒ Slope Failure
- ☒ Settlement
- ☐ Soil Liquifaction
- ☐ Fault Movement
- ☐ Other
- ☐ No Damage
- ☐ N/A

COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
   - 3a. In-House Repair Possible
   - 3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:

SAFE (Green Tag): __X__ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE(Red Tag): _____

Name of the Inspector(s): JOE INSPECTOR

FIGURE 5.26 Completed Level 2 Inspection Form, Bridge Example 2

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APPENDIX

INDOT VINCENNES DISTRICT RESPONSE PROCEDURES FOR MAJOR DISASTERS

MAJOR DISASTER: A major disaster is defined as any incident that could cause extended closure of our highway system. Examples could be localized incidents like fire, winds, tornado, vehicle accidents and spills or non-localized incidents such as floods, ice storms, blizzards, nuclear incidents or earthquakes (Intensity > 5.0 Magnitude). All INDOT personnel should participate in appropriate disaster training and following a perceived disaster (and phones do not work) report to their designated reporting station or the closest Unit to their home.

DISTRICT RESPONSE: As soon as possible following a major disaster incident, the Vincennes District will open their District Emergency Operations Center (DEOC). Communications will be established between affected subdistricts and central office. The Vincennes Emergency Operations Center will be located in the new District Office building on US 41 just south of Vincennes. The District presently has a 24-hour switchboard attendant. The DEOC will be staffed by select department heads and designated staff.

SUBDISTRICT RESPONSE: As soon as possible following a major disaster, each affected Subdistrict will open their Subdistrict Emergency Operations Center. Communications by phone and radio will be established with all affected Subdistrict units and the Vincennes District. Subdistricts should establish procedures to contact those people needed to perform disaster activities including a system of notification if telephones are not working. The Subdistrict EOC will be staffed by designated Subdistrict personnel with help from the other departments. If a Subdistrict is not operational, an adjacent Subdistrict will take over as the Subdistrict EOC.

UNIT RESPONSE: As soon as possible following a major disaster, each affected Unit will open their facility, establish communications by phone and radio and start Level 1 Inspections of all Unit Primary Routes (Most units have 2 to 3 Primary Routes). Designated personnel from other

departments (such as construction) are to be assigned to the closest unit to assist that unit or personnel may be sent between units as the need is identified.

UNIT LEVEL 1 INPECTIONS: Each Unit involved in the disaster will be responsible for the Level 1 Inspection of the Units Primary Routes if the respective disaster warrants. Assigned Unit personnel (normally two people per route) will pick up an Inspection Kit from their disaster cabinet and inspect their assigned primary route reporting back the condition of the roadway and all bridges on that route. Primary routes are road sections needed for access to critical areas such as cities, hospitals, schools, industries, adjacent States. Once primary routes are inspected the supervisor will determine if the secondary routes should be inspected. The Level1 Inspection will be a visual assessment with short stops to inspect all bridges. It is important that Level 1 Inspections should be completed as quickly and accurately as possible so that a quick assessment of the disaster can be made. Only interrupt your Level 1 Inspection to assist with a life-threatening situation.

DURING THE LEVEL 1 INSPECTION:

1. Minor roadway deficiencies should be recorded on the Level 1 Inspection Form including pavement damage, earth embankment failures, road obstructions and failure of traffic control devices. Any roadway damage requiring the closing of the roadway should be relayed back to the Unit / Subdsitrict / District office immediately. Each inspection crew will carry a set of Road Closure Signs to be used in such an event.
2. All bridges are to be inspected using the Level 1 Inspection Form with bridges identified. Approach all bridges with caution and never walk directly under a bridge following an earthquake. Do not cross the bridge without first sighting down the curb/rail line and checking the underside for structural damage. Do not cross the bridge if significant problems are observed. Close the bridge by placing Road Closed Signs on each approach and place a Red Ribbon with time, date and your initials on the bridge signpost. Use the provided State/County Map to find a route around closure. If the bridge is passable but repairs are needed place a Yellow Ribbon or place a Green Ribbon if no problems are found. Place ribbons on bridge sign post just under the sign and remember to time/date/initial for possible follow up inspections. Record all observations and proceed to the next structure. Level 1

Inspection Training for unit personnel will be done in house by District personnel using materials provided by Purdue University.

REQUIRED MATERIALS FOR EACH LEVEL 1 INSPECTION CREW: All noted materials below must be kept in the units Disaster Signal Box located in the yard of each unit.

1. The Units A, B, C,…. Primary Route Maps with detour county maps and state maps and inspection procedures (in box).
2. Red Ribbon to close, Yellow Ribbon to identify open but repairs needed and Green Ribbon to denote undamaged with color wording on ribbon (in box).
3. A tablet with waterproof markers, pen, pencil (in box).
4. Load one set (2 signs) of "Road Closed" signs with B flashers and stands.
5. Load shovel/barrels/cones/traffic control paddles (from unit) in truck.
6. Flashlight, fire extinguisher, hard hats, vests, first aid kit and personal items should go with each radio equipped Level 1 Inspection truck.

LEVEL 2 INSPECTION TEAM: Each unit reporting roadway or bridge damage requiring Closure (red) or Damage (Yellow) will report it back to the Unit/Subdistrict/District who will assign a Level 2 Inspection team to do more in-depth inspection of the damage. The Level 2 Inspection team will be a minimum two-person team made up of at least one trained professional engineer (CE) or experienced project supervisors (EAS). A list of Level 2 trained personnel assigned to each Subdistrict/Unit will be kept on file. Level 2 personnel will be formally trained using materials provided by Purdue University. Unless assigned otherwise each CE & EAS is to report to the closest unit to their home.

LEVEL 3 INSPECTION TEAM: If additional inspection is needed it will be initiated by CO using in-house design personnel or consultants.

COMMUNICATIONS: It is likely to be a major problem in any disaster. INDOT will prepare for the loss of phones and radio towers by setting up a mobile to mobile system by strategically locating 100 watt radio equipped maintenance vehicles to relay to any part of the district. A letter identifying 100-watt vehicles and a map where vehicles are to be located shall be kept in each

disaster kit at the Subdistrict. Traffic will make operational a boom truck that will have an antenna capable of working as a temporary tower. All subdistricts will maintain their emergency power generations and wiring will be done at units to allow the connection of a portable generator for emergency power. During any such disaster minimize your use of the radio and phone to only critical information such as road closures.

MAJOR DISASTER PROCEDURES FOR UNITS:

The first person to arrive at the Unit should gain access and then:

1. Turn off the incoming gas if the Unit building has been damaged or if gas is smelled (earthquake/tornado). Do not turn on lights prior to checking for leaking gas. The gas valve with wrench is located _____. Also, if electricity is damaged, you may want to disconnect the breaker or shut off water if a leak is discovered. Units should label all critical gas and water valves. If no key is available access may have to be gained by cutting/breaking locks.
2. Establish communications with the Subdistrict by telephone and radio and start the Unit Communications Log, always have someone assigned to monitor communications. If a phone connection is made with the Sub you may want to leave it open and not hang up to maintain an open line. Each unit shall id vehicles with 100-watt radios and assigns them to relay locations such as the unit and strategic hilltops if towers are down.
3. Unlock all doors, locate vehicle keys and start emergency generator, if available and as needed. Extra vehicle keys may need to be stored in the Units Disaster Signal Box if your unit building is likely to be affected (older brick buildings). A complete set of backup vehicle/facility keys should be kept at the Subdistrict.
4. As additional personnel report to the Unit, they should immediately start the Units Primary Route Level 1 Inspections unless directed otherwise by the Subdistrict. You should assign two maintenance workers to each primary route. All materials for the inspection should be available in the Disaster Signal Cabinets or unit.
   A. Sign the route assignment sheet and pick up the primary “A” route kit. Later workers will pick up routes B or C until all routes are being inspected.

B. Each Inspection Kit will include a primary route map with detour state and county maps and inspection procedure, Red Yellow and Green Ribbon, tablet, waterproof marker, pen and pencil.

C. Load your radio-equipped truck with 2 road-closed signs, B flashers and stands, shovel, barrels, cones and traffic control paddles.

D. Vehicle should already contain flashlight, fire extinguisher, hard hats, vests, first aid kit and personal items such as food, water and clothing.

E. Driver should read instructions and begin the Primary Route Level 1 Inspection.

F. When the Primary Route Inspection is completed and you have returned to the Unit, sign in on the route assignment sheet and report to your supervisor.

G. If all routes have been assigned for inspection additional personnel who arrive should prepare equipment for possible use.

DISASTER ROAD/BRIDGE CLOSURE PROCEDURE

INDOT has a formal procedure for the planned closing of a road or bridge that includes pre-closure notification to the public (through the media & signs), marking a detour/approach and signing the actual barricade closure. In a major disaster, this procedure will be impossible to follow but INDOT has a responsibility to take all reasonable actions to notify and protect the public as soon as the need for a road closure is known. To that end each unit shall maintain a minimum of one set of "Road closure" signs with type B flashers and sign supports for each primary disaster route in their unit. The Level 1 inspectors shall load one Road Closure setup (2 signs) onto their truck prior to starting their inspection. If the need for a closure is encountered during the inspection, the signs will be put on each approach and the Unit/Subdistrict will be immediately notified by radio so that the approach signing, barricading and a detour can be placed in a timely manner by follow up personnel. Once the sign is placed the Level 1 inspectors shall continue the inspection on their primary route using the state and county maps to find a way around the closure. If additional closures are encountered that information is to be relayed back to the Unit/Subdistrict for assistance. One inspector may have to remain at the closure until relieved if no signing or other traffic control is available (try to use local law enforcement if available). The Sub is complete State Form 1866 to notify other agencies of the emergency

closure. Remember that the Level 1 inspection must be done as quickly and accurately as possible so a determination of the extent of damage can be made and repairs started.

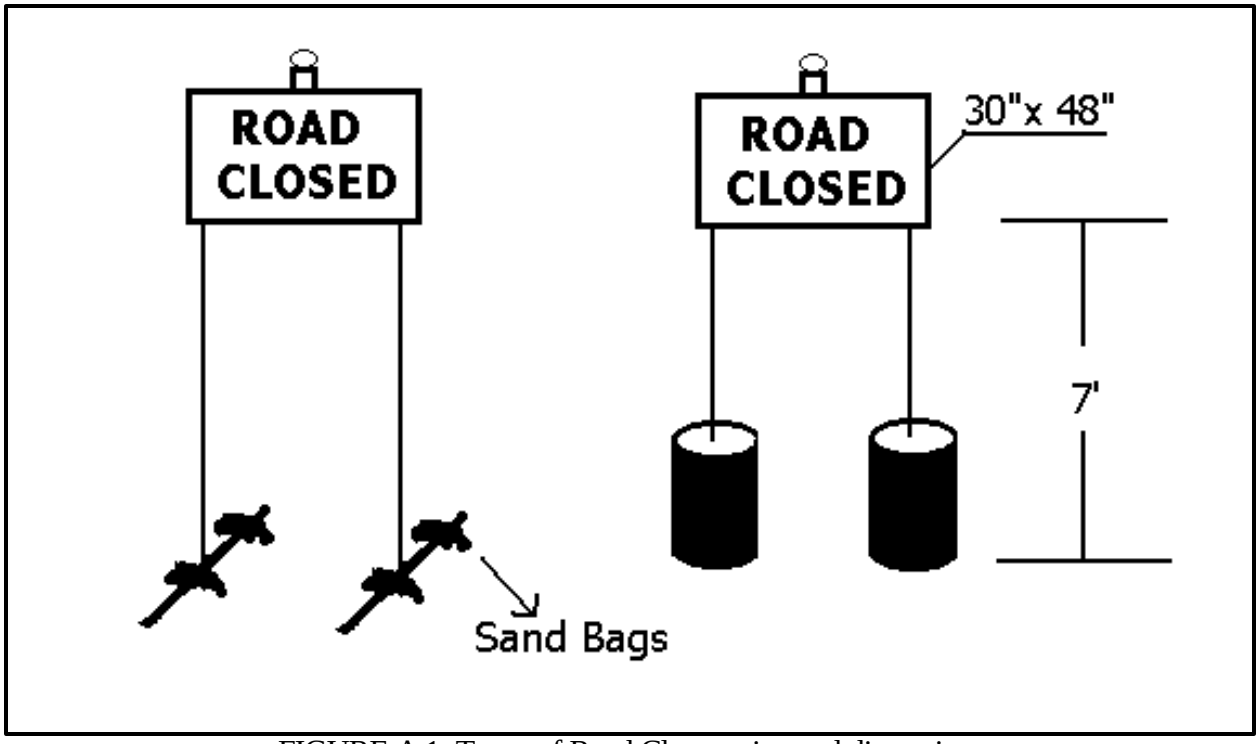

FIGURE A.1 Types of Road Closure sign and dimensions

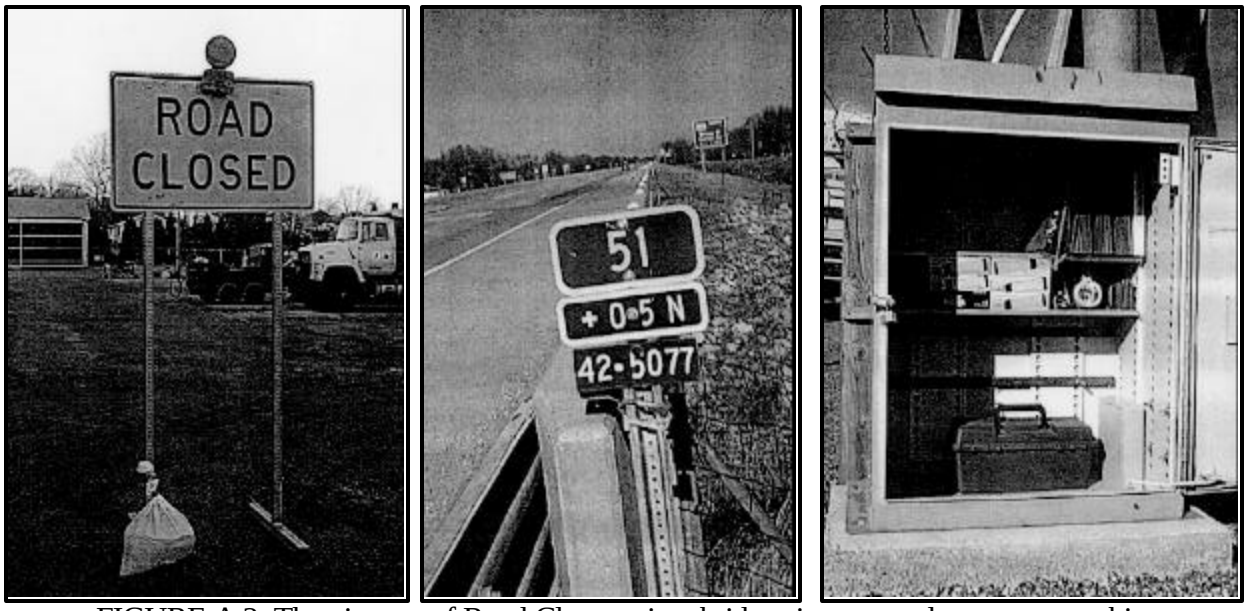

FIGURE A.2 The pictures of Road Closure sign, bridge signpost and emergency cabinet

PROPOSED PRIMARY DISASTER ROUTES:

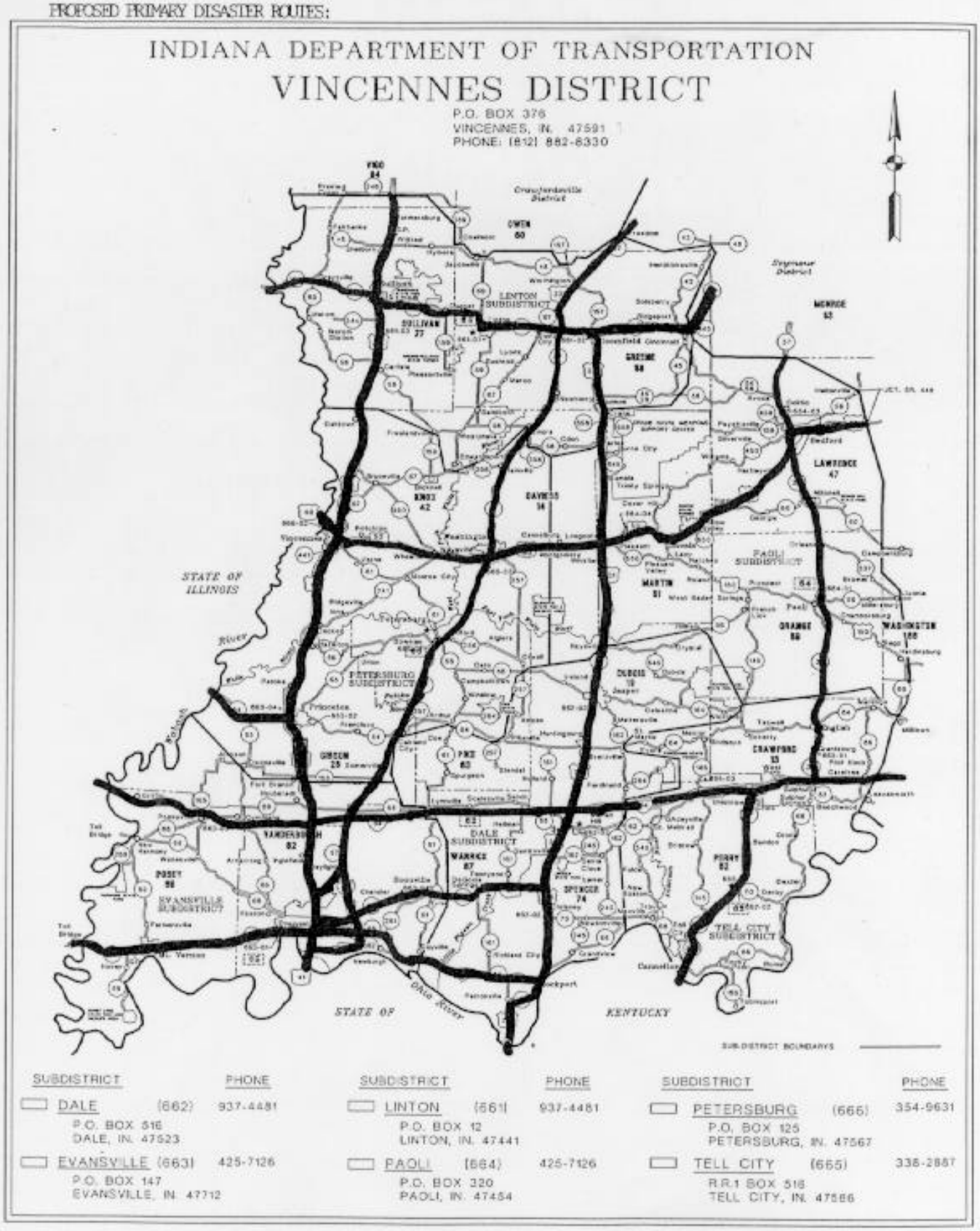

FIGURE A.3 The map of primary routes in Vincennes District

EARTHQUAKE PREPAREDNESS

BEFORE

Develop a family earthquake plan. Prepare yourself, your family and your home by completing the activities on this checklist.

- Decide how and where your family will reunite if separated.
- Choose an out-of-state friend or relative that separated family members can call after the quake to report their whereabouts and condition.
- Know the safe spots in each room: under sturdy tables, desks, against inside walls.
- Know the danger spots: windows, mirrors, hanging objects, fireplaces, bookcases, tall and unsecured furniture.
- Conduct practice drills. Physically place yourself in safe locations.
- Learn first aid and CPR (cardiopulmonary resuscitation) from your local Red Cross chapter or other community organizations.
- Keep a list of emergency phone numbers.
- Learn how to shut off gas, water and electricity in the case the lines are damaged. (Safety note: Do not attempt to relight gas pilot)
- Secure water heater and appliances that could move enough to rupture lines.
- Secure heavy furniture, hanging plants, heavy pictures or mirrors.
- Keep flammable or hazardous liquids in cabinets or on lower shelves. Put latches on cabinet doors to keep them closed during shaking.
- Maintain emergency food, water and other supplies, including a flashlight, a portable battery-operated radio, extra batteries, medicines, first aid kit and clothing (for 3 day long).

DURING

If indoors, stay there, take cover under a table, desk, or other sturdy furniture:

- Face away from windows and glass doors.
- Doorways without doors are OK also.
- Lay, kneel, or sit near a structurally sound interior wall or corner away from windows, brick fireplaces, glass walls.
- Protect your head and body from falling or flying objects.
- Remain until shaking stops. Think out your plan of action first, and then move.
- Know exit routes if in commercial building. Take cover, don't move till shaking stops.

If outside, get into an open area away from trees, buildings, walls and power lines:

- Lie down or crouch low to maintain balance.
- Get to best available shelter if there not open area available.

If driving, stop safely as soon as possible. Stay inside until the shaking stops:

- Do not stop under overpasses or bridges.
- Stay below window level in your car.
- Turn off engine.
- Turn on radio. Fellow emergency instructions.
- Stay in vehicle if downed power lines have fallen across it. You are insulated by the tires. Wait for help. You might be able to back away from lines.
- If you have to leave your vehicle, move to open area quickly.

AFTER

Check for injuries. Apply first aid. Do not move seriously injured individuals unless they are in immediate danger.
Do not use the telephone immediately unless there is a serious injury or fire.

- Check utilities (water, gas, electric). If there is damage turn utility off at the source.
- Check for other hazards and control them (fire, chemical spill, toxic fumes and precarious collapse).
- Check building for cracks and damage, including roof, chimneys, and foundation.
- Check food and water supplies.
- Emergency water can be obtained from water heaters, melted ice cubes, canned vegetables, and toilet tanks.
- Never use matches, lighters or candles inside.
- Turn on radio and listen for emergency broadcasts/announcements, news reports, and instructions. Cooperate with public safety officials.
- Do not use your vehicle unless there is an emergency. Keep the streets clear for emergency vehicles.
- If buildings are suspect, set up your shelter area away from damage.
- Work together with your neighbors for a quicker recovery. Stay calm and lend a hand to others.
- Be prepared for after shocks.
- Plan for evacuation in case events make this necessary. Leave written messages for other family members or searchers.
- Use gloves, wear heavy shoes, have adequate and appropriate clothing available.
- Contact to your work site and report

INDOT RAPID ASSESSMENT BRIDGE INSPECTION REPORT (LEVEL I)

Route_____ Direction_____from Intersection_____ Page:____of _____

Date and Local Time:

Post Earthquake Condition of the Bridge (Please write "YES, NO or DRN (Detailed Review Needed)" for items 1-6)

Bridge Number	**1. Collapse / Partial Collapse/ Roadway Closed**	**2. Superstructure Damage** Movement, Pounding, Buckling, Cracking, Failure	**3. Substructure Damage** Shear Key Damage, Local Buckling, Settlement, Tilting, Sliding, Rotation, Cracking, Failure	**4. Bearing Damage** Failure, Movement, Shearing or pullout of bolts	**5. Soil Problems** Slope Failure, Soil Liquefaction, Fissure, Differential Settlement	**6. Secondary Structure Damage** Wing walls, Parapets, Pylons	**7. Explain Other Problems Observed (Damage in Pipelines or Other Utilities etc.)**	**RED TAG**	**YELLOW TAG**	**GREEN TAG**
	YES NO DRN	**YES NO DRN**	**YES NO DRN**	**YES NO DRN**	**YES NO DRN**	**YES NO DRN**				

Roadway Problems Encountered and Comments:

Name of the Inspector(s)

INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route:	Date and Local Time:
Bridge ID:	Bridge Location :

DAMAGE OBSERVED:

1. ROADWAY/APPROACHES

- ☐ Not Operational
- ☐ Roadway Settlement
- ☐ Off Bridge Seat
- ☐ Excessive Transversal Movement
- ☐ No Damage
- ☐ Other (explain)

2. DECK

- ☐ Longitudinal Joints Enlarged
- ☐ Expansion Joints Enlarged
- ☐ Wearing Surface Cracking
- ☐ Wearing Surface Spalling
- ☐ Deck Cracking/Spalling
- ☐ Misalignment of Guard Rails, Curbs, Pavement Lines
- ☐ No Damage

3. BEARINGS

- ☐ Failure of Bearings (Integral, Contact, Rocker, Elastomeric)
- ☐ Movement of Bearings
- ☐ Shearing or Pullout of Bolts
- ☐ No Damage

4. SUPERSTRUCTURE

Reinforced Concrete Slab
☐ Flexural Cracks ☐ Shear Cracks
☐ Connection Failure ☐ No Damage ☐ N/A

Culverts
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Connection Failure
☐ Metal Pipes Distortion & Deflection ☐ No Damage ☐ N/A

Steel Truss Members, Floor Beams, Stringers
☐ Local Buckling ☐ Upper Chord ☐ Lower Chord ☐ Diagonals
☐ Connection Failure ☐ No Damage ☐ N/A

Concrete Arches
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure
☐ Spandrel Wall Cracking/Collapse ☐ No Damage ☐ N/A

Steel/Concrete Girders, Beams
☐ Flexural Cracks ☐ Shear Cracks ☐ Connection Failure ☐ Local Buckling
☐ No Damage ☐ N/A

5. SUBSTRUCTURE

Abutments
☐ Wall Movement/Rotation ☐ Pounding Damage ☐ Wing wall Movement
☐ Wing wall Separation ☐ Backfill Settlement ☐ Foundation Movement
☐ Abutment Pile Damage ☐ Cracking on the Walls ☐ No Damage ☐ N/A

Piers
☐ Joint Failure ☐ Moment Failure ☐ Shear Failure ☐ Inadequate Splice Failure
☐ Flexural Cracks ☐ Shear Cracks ☐ Local Buckling ☐ Foundation Failure
☐ No Damage ☐ N/A

6. GEOTECHNICAL

- ☐ Slope Failure
- ☐ Settlement
- ☐ Soil Liquefaction
- ☐ Fault Movement
- ☐ Other
- ☐ No Damage
- ☐ N/A

COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
   3a. In-House Repair Possible
   3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:
SAFE (Green Tag):_____MORE REVIEW NEEDED (Yellow Tag) _____UNSAFE(Red Tag):_____
Name of the Inspector(s):