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16. Abstract The nation's infrastructure is full of deteriorating bridges in need of replacement or rehabilitation – oftentimes using accelerated bridge construction (ABC) techniques. The first step in any of these projects is to demolish (either entirely or in part) the existing structure. While the AASHTO LRFD Bridge Design Specification identifies minimum bridge design requirements and the AASHTO LRFD Construction Specification stipulates the bridge construction aspects, there is limited information available to guide design engineers and contractors on how to approach bridge demolition. Recent unintentional events have further exposed the need for research in this area. The purpose of this research is to get a national perspective on the administration practices owners use for bridge demolition. This was done in a survey developed through cooperation with the Research Advisory Panel (RAP) and distributed to all State Departments of Transportation (DOTs). The results of this summary were compiled and are presented in this report. These results show that additional research should be conducted on the topic.			
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Compilation of Results from Bridge Demolition DOT Survey

Final Report – Phase I

September 2016

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Thanks should also be given to Carmen Swanwick and Benjamin Beerman for their guidance throughout these research efforts.

The author would like to thank the Research Advisory Panel members: Carmen Swanwick (panel chair, Utah DOT), Benjamin Beerman (FHWA), Ahmad Abu-Hawash (Iowa DOT), Mike Culmo (CME Associates, Inc.), Tim Davis (PCL), Richard Dunne (Michael Baker International), Tim Keller (Ohio DOT), Mary Lou Ralls (Ralls-Newman, LLC), Corey Rogers (Michigan DOT), and Wayne Symonds (Vermont Agency of Transportation).

EXECUTIVE SUMMARY

The nation's infrastructure is full of deteriorating bridges in need of replacement or rehabilitation – oftentimes using accelerated bridge construction (ABC) techniques. The first step in any of these projects is to demolish (either entirely or in part) the existing structure.

The AASHTO LRFD Bridge Design Specifications identify the minimum bridge design requirements, while the AASHTO LRFD Bridge Construction Specifications stipulate bridge construction aspects. However, very limited information is available to guide both design engineers and contractors on how to approach the demolition of an existing bridge. This lack of available information has led to each state approaching bridge demolition work very differently.

Unintentional events during bridge demolition can result in bodily harm, project delays, traffic disruptions, and in some instances loss of life. In less than one year, two worker fatalities have occurred on two separate occurrences due to the collapse of bridge structures while undergoing demolition. The first occurred in Orange County, CA in May of 2014; the second occurred in Cincinnati, OH in January 2015. While these events may be considered low probability, the outcomes are of high consequence. The bridge design and construction industry has a duty to evaluate bridge demolition from a national perspective and provide best practices to improve upon the safety to both the workers and the traveling public.

The research conducted for this report was done in response to a research needs statement (RNS) developed by AASHTO SCOBS T-4 and the TRB Subcommittee for ABC, originally only considering accelerated bridge demolition. Given that many aspects of bridge demolition impact both conventional as well as accelerated construction, it was decided to modify the scope to bridge demolition in general. Additionally, the first step in the larger project was determined to be to first gather a better assessment of the current practices that are occurring nationally. This task was accomplished through a survey developed through cooperation with the Research Advisory Panel (RAP) and distributed to all State Departments of Transportation (DOTs). The results of this summary were compiled and are presented in this report.

A summary of the main findings of the survey are as follows. A quarter of responding states have experienced an accidental incident and 43-percent have experienced an unintentional collapse in the past 15 years. These proportions show that problems with bridge demolitions are not isolated to only a few states. Of the incidents that occurred, the majority occurred during conventional construction projects or rehabilitation and repair projects. Only one accidental incident and one unintentional collapse occurred during bridge projects with any accelerated construction technique. The majority of incidents occurred on bridges either over closed roadways or waterways. Two accidental incidents and one unintentional collapse occurred over a roadway open to the public. About one-quarter of the accidental incidents that occurred resulted in injury or loss of life, while about half of the unintentional collapses resulted in injury or loss of life. Of these, most of the injuries were to contractor employees.

Only 38-percent of responding states have criteria, guidelines, or procedures for when a set of contract plans require the inclusion of a demolition plan. Over 50-percent of responding states have projects that do not require detailed demolition plans to be submitted. The majority of responding states (69-percent) do not see alternative delivery methods posing an additional risk. Only a small percentage of states (11-percent) conduct a risk assessment prior to determining the requirement for bridge demolition plans.

Only 33-percent of responding states either sometimes require a design engineer (26-percent) or always require a design engineer (7-percent) in the development of demolition plans. The majority of responding states (77-percent) do not specify any parameters for demolition equipment.

Most states either do not require a pre-demolition meeting (48-percent) or require but do not document (11-percent). Most responding states (40-percent) never require the submission of contractor qualifications with the demolition plans.

From a national perspective (based on a low extrapolated estimate from actual survey results), the information collected may indicate approximately 27 to 33 accidental incidents and approximately 27 to 33 unintentional collapses have occurred over the past 15 years in the US and have resulted in about 20 to 24 injuries and 8 to 10 fatalities.

CHAPTER 1: INTRODUCTION

1.1. Project Motivation

The nation's infrastructure is full of deteriorating bridges in need of replacement or rehabilitation – oftentimes using accelerated bridge construction (ABC) techniques. The first step in any of these projects is to demolish (either entirely or in part) the existing structure.

The AASHTO LRFD Bridge Design Specifications[1] identify the minimum bridge design requirements, while the AASHTO LRFD Bridge Construction Specifications stipulate the bridge construction aspects. However, very limited information is available to guide both design engineers and contractors on how to approach deconstruction or the removal aspects of an existing bridge. The design and construction codes provide very little direction on demolition, and each state approaches this work very differently.

Unintentional events during bridge demolition can result in bodily harm, project delays, traffic disruptions, and in some instances loss of life. In less than one year, two worker fatalities have occurred on two separate occurrences due to the collapse of a bridge structure while undergoing demolition. The first occurred in Orange County, CA in May of 2014[2]; the second occurred in Cincinnati, OH in January 2015[3]. While these events may be considered low probability, the outcomes are of high consequence. The bridge design and construction industry has a duty to evaluate the demolition aspects of bridge construction from a national perspective, and provide a best practices guideline to improve upon the safety to both the workers and the traveling public.

1.2. Research, Objectives, and Tasks

The main objective of this research was to survey State Department of Transportation (DOT) officials to gather information concerning the state of practice for bridge demolition. The research was divided into the following tasks:

1. Assemble research subcommittee
2. Develop survey
3. Administer survey
4. Compile survey results
5. Provide recommendations for future work
6. Prepare final report

The research work should be used to further guide and direct the future of bridge demolition.

1.3. Research Advisory Panel (RAP)

The project work and the developed survey were done in collaboration with the Research Advisory Panel (RAP). The following people participated in the RAP:

- Carmen Swanwick (Utah DOT) – RAP Chair
- Benjamin Beerman (FHWA) – TRB Subcommittee on ABC Chair
- Ahmad Abu-Hawash (Iowa DOT)
- Tim Keller (Ohio DOT)
- Corey Rogers (Michigan DOT)
- Wayne Symonds (Vermont Agency of Transportation)
- Richard Dunne (Michael Baker International)
- Mike Culmo (CME Associates, Inc.)

- Tim Davis (PCL)
- Mary Lou Ralls (Ralls-Newman LLC)

1.4. Report Overview

This report is intended to summarize the results of the bridge demolition survey developed by the ABC-UTC and RAP and guide future research done in this area.

CHAPTER 2: DEVELOPED SURVEY

A survey was developed with the guidance of the RAP. The survey was broken down into the following sub-categories:

1. Background Questions
2. Past Incidents and Collapses
3. Liability
4. Requirements of Bridge Demolition Plans
5. Information Required for a Bridge Demolition Submittal
6. Approval of Bridge Demolition Submittal (Prior to Work)
7. Construction Engineering Inspection / Field Oversight (During Work)
8. Closing Questions

The developed survey was sent out to all fifty state DOTs and responses were gathered. This chapter introduces the survey and the developed questions.

2.1. Introduction to Survey

The United States bridge industry has recently experienced several unintentional bridge collapses during bridge removal and rehabilitation operations that have attracted national attention. Although few in number, the consequences from these events can be significant from many perspectives. In response to these occurrences, the AASHTO Subcommittee on Bridges and Structures Technical Committee for Construction (AASHTO T-4) and the Transportation Research Board Subcommittee on ABC requested research to gain a better understanding of bridge demolition at a national level. In response, the ABC-UTC conducted preliminary research efforts to serve as a means to direct future work.

Results of the survey will follow in Chapter 4 and will be used by AASHTO T-4 to make recommendations in an effort to address knowledge gaps, share best practices, and be a guide for action items moving forward.

Several key terms were defined for the purpose of the survey, as shown in Table 2.1.

Table 2.1: Definitions of key terms for survey

Term	Definition
Bridge Demolition	Either the complete or partial removal of a bridge deck, superstructure, substructure, or any combination of these. Culverts/buried structures are not part of this survey
Bridge Collapse	Either the partial or entire deck, superstructure, or substructure (i.e. structural element) is no longer functioning in its intended purpose or state before, during, or after a bridge demolition activity
Accidental Incidents	Inadvertent events occurring during bridge demolition (either partial or full), which could have resulted in a bridge collapse (as defined above) but did not

Term	Definition
Unintentional Collapse	Unintentional events occurring during bridge demolition (either partial or full) that resulted in a bridge collapse (as defined above)
Administered	A general term used to describe the review, approval/ acceptance/concurrence, and/or oversight/construction inspection of the contractor's demolition plan and demolition activities

2.2. Background Questions

The objective of the background questions was to gather basic information of the participant's location and affiliation. The survey was designed to be given to all parties affiliated with bridge demolition, although only responses from state DOT bridge owners were gathered in this initial study.

Question 1	Please state your state.
Question 2	Please select your affiliation: a) State Department of Transportation b) County/City Bridge Owner c) Contractor d) Consultant

2.3. Past Incidents and Collapses

The survey authors assumed that there were likely bridge collapses and other incidents that happened without attracting media attention. The objective of these questions was to obtain information on accidental incidents and unintentional collapses that may not have been reported otherwise.

Question 3	Within the past 15 years, have you or your agency experienced any (check all that apply): a) Accidental Incidents (close calls/near misses) b) Unintentional Collapses (down, but not in the anticipated manner) c) Other demolition related events

The following questions were provided for each of the three categories of Question 3. The questions shown below are for "Accidental Incidents", but the other two categories were also investigated with similar questions.

Question 4	How many Accidental Incidents have occurred in the past 15 years?
Question 5	These Accidental Incidents were involved in (check all that apply): a) Conventional construction projects b) Accelerated bridge construction projects c) Projects involving any accelerated construction activities d) Emergency projects e) Rehabilitation or repair projects f) Other
Question 6	These Accidental Incidents resulted in injury to (check all that apply): a) n/a (no injuries occurred) b) Contractor c) Public d) Staff e) Other
Question 7	These Accidental Incidents resulted in loss of life to (check all that apply): a) n/a (no injuries occurred) b) Contractor c) Public d) Staff e) Other
Question 8	Please provide project names, brief descriptions of the challenge or incident, and/or contact information for related parties.
Question 9	What was the bridge demolition project over? a) Closed road b) Open road c) Waterway d) Nothing e) Other
Question 10	Was a post incident report developed?

Questions 11 through 24 were similar but for Unintentional Collapses and Other Demolition Related Events.

2.4. Liability

Considering contract documents are different for every state, the survey asked how liability is handled.

Question 25	Describe your Agency's overall position on the liability of bridge demolition activities?
Question 26	Is your Agency's positon on the liability of bridge demolition activities effective? (i.e. in terms of safety, prevention of unintentional incidents and collapses, exposure to litigation, public trust, etc.)

2.5. Requirement of Bridge Demolition Plans

The bridge demolition plans are generally put together by the contractor and do not always require a licensed engineer's review and approval. These questions were created to gain a better understanding of each Agency's policy regarding demolition plans.

Question 27	Does your Agency (or the Agency you work for) have criteria, guidelines, or procedures for when a set of contract plans require the inclusion of a demolition plan? a) Yes (prior to bid) b) Yes (after award) c) No d) Other
Question 28	If yes, can you please provide a hyperlink?
Question 29	When is a detailed demolition plan required? a) Never b) For partial bridge demolition c) For full bridge demolition d) Other (text entry)
Question 30	Are there types of projects where the contract documents do not include a detailed demolition plan and the contractor is not required to prepare one or submit one? a) Yes/No/Other b) If yes, what types of projects do not require a detailed demolition plan?

Question 31	Are there criteria in which bridge demolition plans are submitted and administered for projects procured under alternative delivery methods (e.g. Design/Build, Design/Bid/Build, Detailed Build, P3, CMGC, etc.)?
Question 32	Do you see alternative delivery methods as a risk to your Agency regarding bridge demolition activities?
Question 33	Does your Agency conduct a risk assessment to determine when and at what level a bridge demolition plan should be developed and/or submitted?

2.6. Information Required for a Bridge Demolition Submittal

When the contractor is conducting a demolition, there are different requirements for the information that must be submitted to the bridge owner and when the design engineer must be involved in the process. The questions of this section were created to determine the requirements.

Question 34	When is the design engineer (whether it be consultant or in-house) required to prepare demolition documents for submittal to the owner: a) Always b) Sometimes c) Never d) Other
Question 35	If required, at what point is the design engineer required to prepare demolition documents: a) Design phase b) Construction phase (hired by contractor) c) Other
Question 36	Under what circumstances is a design engineer required to be involved in the development of demolition documents?
Question 37	If a design engineer is involved, to what extent? (check all that apply): a) Create contract plans b) Review contractor plans c) Ensure contractor plans executed as designed d) Other (text entry)
Question 38	Does the demolition plan always need to be signed by a PE?
Question 39	If no, what cases do not require a PE signature?

Question 40	Do you specify analysis parameters for demolition equipment (operating ratings, reduced concrete strength, etc.)?
Question 41	Does your state (or agency) require established contingency plans to be developed prior to the start of demolition to address unforeseen incidents that happen during construction (e.g. an established repair procedure for damaged beams)? If so, please provide the contract document references and the established procedures for review, acceptance, or approval.

2.7. Approval of Bridge Demolition Submittal (Prior to Work)

After the bridge demolition plans are submitted to the bridge owner, there are varying levels of approval that may be required. The objective of this section was to determine the type of review and approval that are required by the bridge owner prior to the start of the demolition by the contractor.

Question 42	What is the degree of oversight your Agency conducts to accept a bridge demolition plan? a) No review by a licensed engineer b) Review but without acceptance or rejection c) Review with concurrence d) Review with acceptance e) Review with approvals f) Other (text entry)
Question 43	If reviewed and an approval is not given, what wording is used in response to the submitter of the demolition plan?

2.8. Construction Engineering Inspection and Field Oversight (During Work)

Once the bridge demolition plan is approved, there are varying levels of inspection and oversight that can be done to ensure the demolition is completed as designed. The objective of the questions in this section was to understand who is responsible for inspection and oversight and the steps that are taken to ensure demolition work is executed as planned.

Question 44	Who is primarily responsible for ensuring the demolition plan is executed as planned? a) Not specified b) Bridge owner c) Engineer of record d) Contractor e) Field engineer (not licensed) f) Field engineer (licensed) g) Other (text entry)
Question 45	A pre-demolition meeting is: a) Not required b) Required, but not documented c) Required and documented d) Other (text entry)
Question 46	Field changes to demolition plans require the approval of (check all that apply): a) Not specified b) Contractor c) Engineer of record d) Bridge owner e) Other (text entry)
Question 47	Is there a mechanism in place to stop field operations if needed? a) Yes/No/Other b) If yes, how are field operations stopped?
Question 48	Are unintentional incidents or collapses reported? a) Yes/No/Other b) If yes, how are these incidents reported?
Question 49	Do you see contract constraints (i.e. limited work windows/time, nighttime only operations, etc.) impacting the manner in which bridge demolition plans are followed?
Question 50	If so, please describe the constraint.

Question 51	Do you allow for traffic to travel under overpass bridges during demolition? a) Yes/No/Other b) If so, do you have specifications for protection of traffic that you can share?
Question 52	When are specific demolition qualifications of contractor, and/or his personnel, required to be submitted to the owner for approval? a) Never (contractor qualifications are never reviewed) b) For complex projects c) For projects with special safety concerns d) For every project

2.9. Closing Questions

The final questions were designed to understand what types of documents or resources would be most beneficial to the parties involved. This document and study were designed to not address means and methods of bridge demolition, but to focus on the administration of bridge demolition. The surveyors did, however, want to gauge national interest with regard to documents that may involve discussion on means and methods.

Question 53	What information or resources would be most beneficial for your agency? a) Best Practices for bridge demolition execution b) Best Practices for bridge demolition administration c) Guide Specification for bridge demolition d) Other
Question 54	Any other comments?
Question 55	Do you have a person or division in your Agency or section overseeing bridge demolition?
Question 56	If yes, please provide contact information.

CHAPTER 3: FULL SURVEY RESPONSES

3.1. Background Questions

A total of 28 states responded to the survey from the states shown in Figure 3.1. Readers of this report whose state is not represented are welcome to contact the author to submit responses. All 28 of the responses were from State DOTs. The question numbers referenced throughout this chapter refer to the survey questions from Chapter 2.

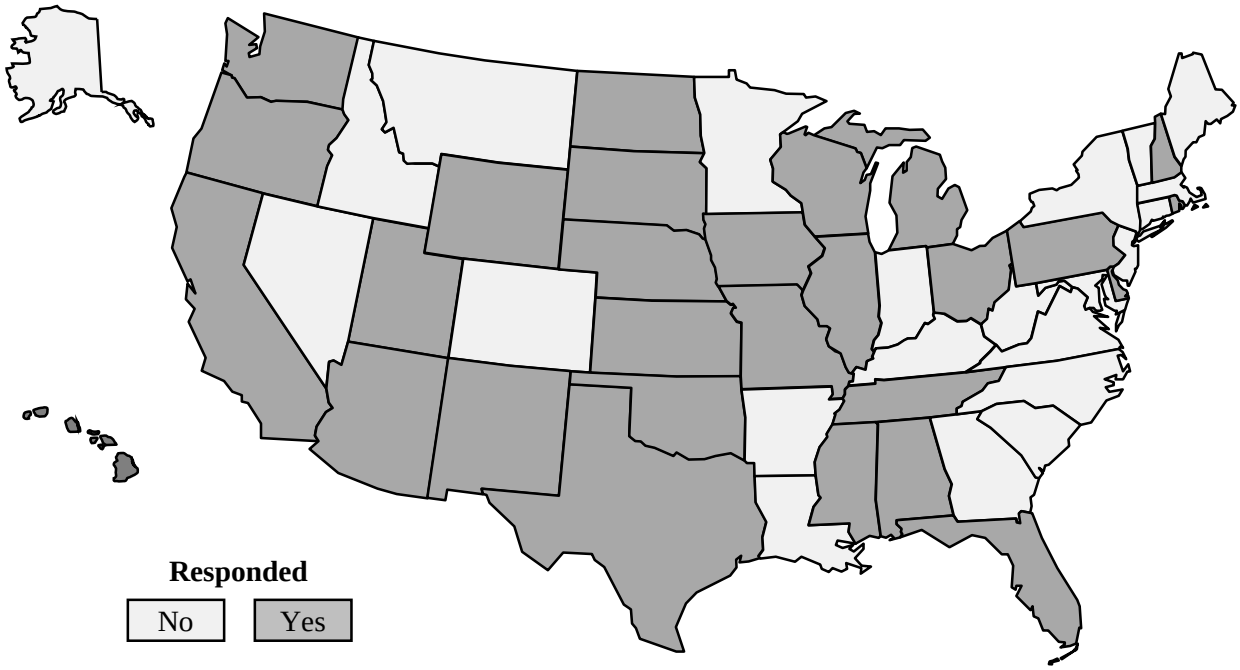


Figure 3.1: States who participated in initial demolition survey (Q1)

3.2. Past Incidents and Collapses

The information presented in this section relates to the past incidents and collapses that were reported by states in this survey; the location of the incidents is not presented. All 28 surveyed states responded to these questions.

The percentage of the responding states which had either an accidental incident, unintentional collapse, or other demolition related event is shown in Figure 3.2. One quarter of the responding states experienced some type of accidental incident and less than half of the states experienced an unintentional collapse in the past 15 years.

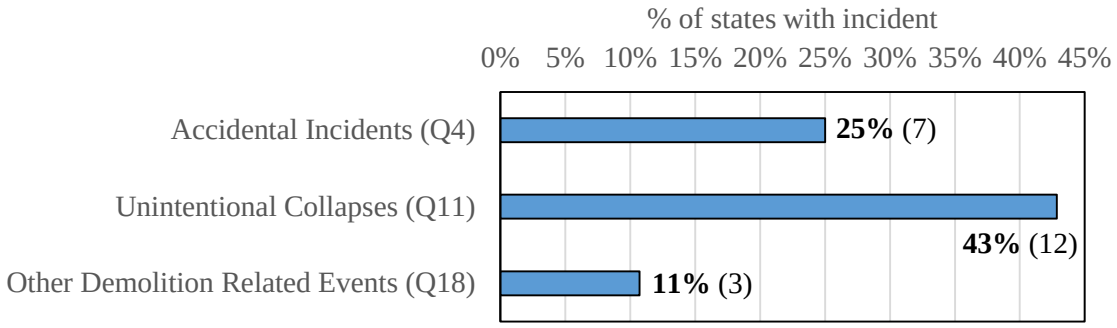


Figure 3.2: Percentage of responding states reporting incidents (Q3)

The total number of accidental incidents, unintentional collapses, and other demolition related events occurring in the past 15 years is shown in Figure 3.3. Sixteen accidental incidents and sixteen unintentional collapses have occurred over this time span and are due to a variety of reasons. These events included collapse to part or all of the existing structures in means that were not planned by the contractor, in some cases damaging adjacent structures and causing disruption to traffic.

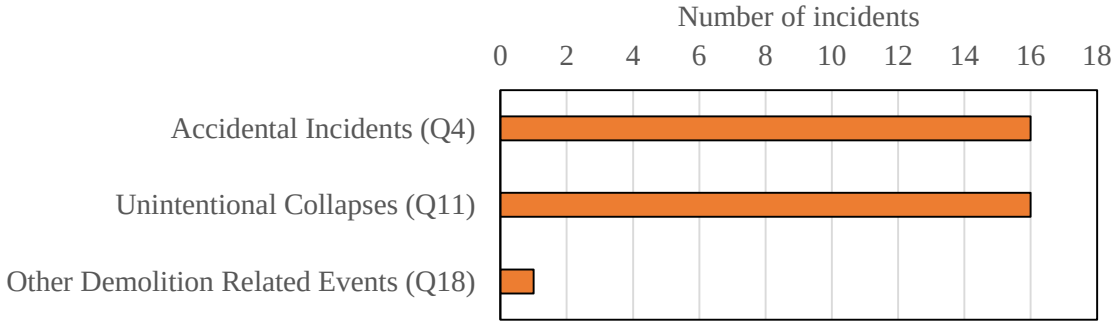


Figure 3.3: Total number of reported incidents

Many reasons were reported as the causes for these accidental incidents or unintentional collapses, but there were several repeat themes. The four main reasons are highlighted in Table 3.1. Note that some incidents had several of these common reasons listed.

Table 3.1: Common reasons for occurrence of accidental incidents or unintentional collapses (summary of Q8, Q15, Q22)

Common Reasons for Incidents or Collapse	# of Incidents
Crane or demolition equipment overloading bridge or used improperly	8
Removal of span or component of continuous span bridge caused other spans to fail	6
Deteriorated members had lower strength than	6

Common Reasons for Incidents or Collapse	# of Incidents
expected	
Demolition plans were not followed in the field	5
Deck removal resulted led to accidental incident or unintentional collapse	5
Error in demolition analysis or poor demolition plans	3

The accidental incidents, unintentional collapses, and other demolition related activities occurred in all different types of construction projects, as shown in Figure 3.4. The majority of these incidents occurred during conventional construction projects, with only two incidents occurring when some type of accelerated construction was utilized.

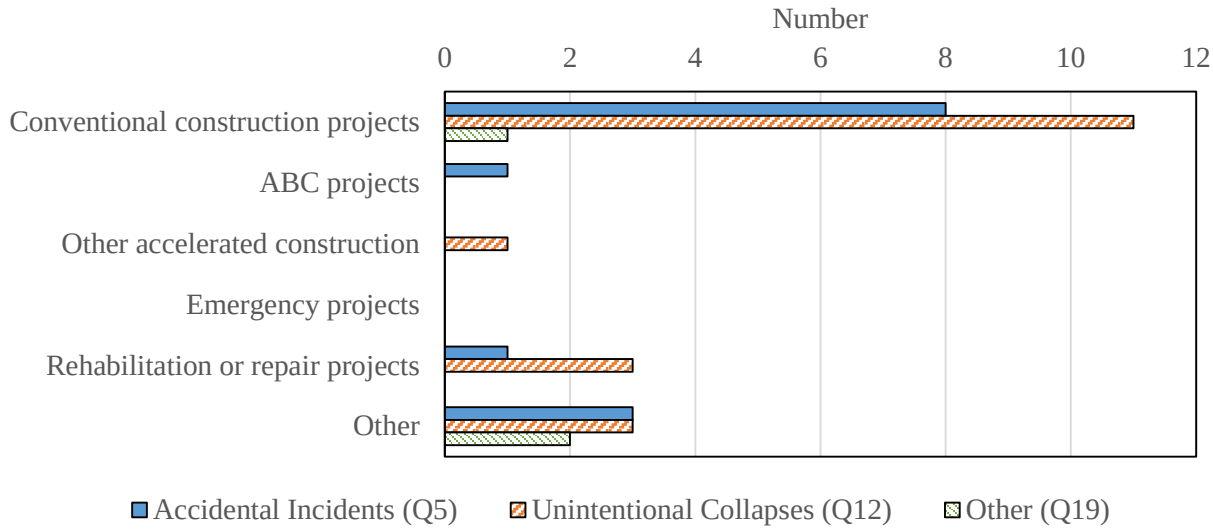


Figure 3.4: Types of projects where incidents occurred

The number of projects in which injuries and fatalities occurred is shown in Figure 3.5. There were a number of injuries or fatalities as a result of accidental incidents and unintentional collapses. Most of these injuries or deaths were to the workers operating the demolition equipment on the structure. It should also be noted that some of these accidental incidents or unintentional collapses were near misses for larger incidents.

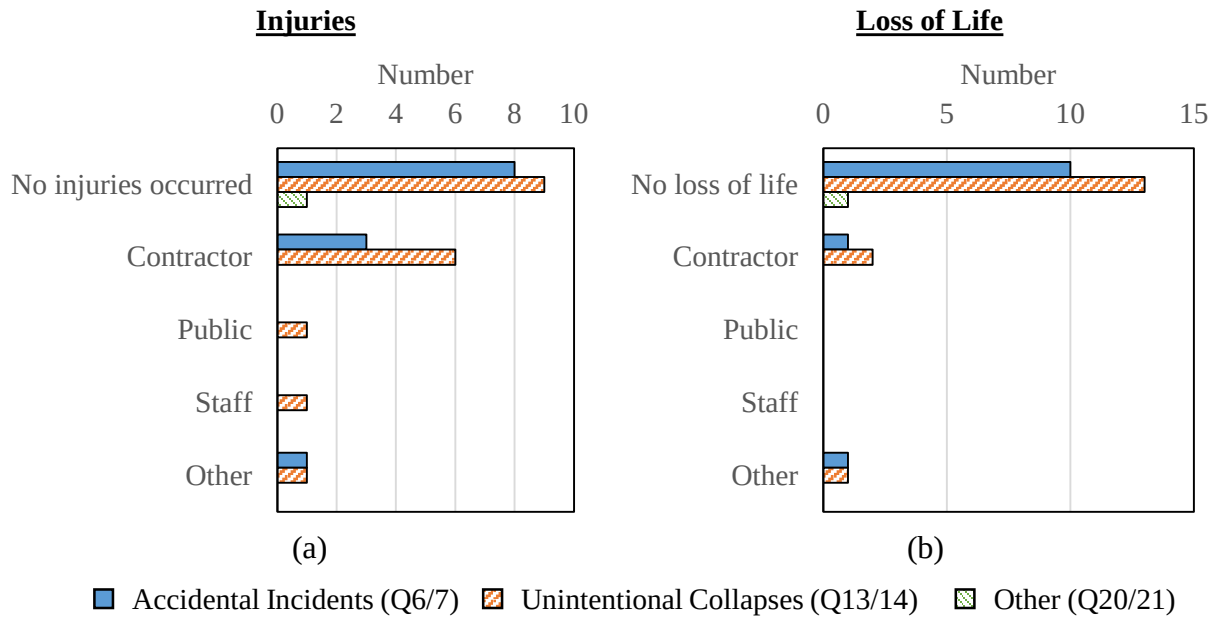


Figure 3.5: (a) Injuries and (b) loss of life resulting from incidents and collapses

The type of features that were underneath bridges experiencing accidental incidents or unintentional collapses are shown in Figure 3.6. Most incidents occurred over closed roadways or waterways.

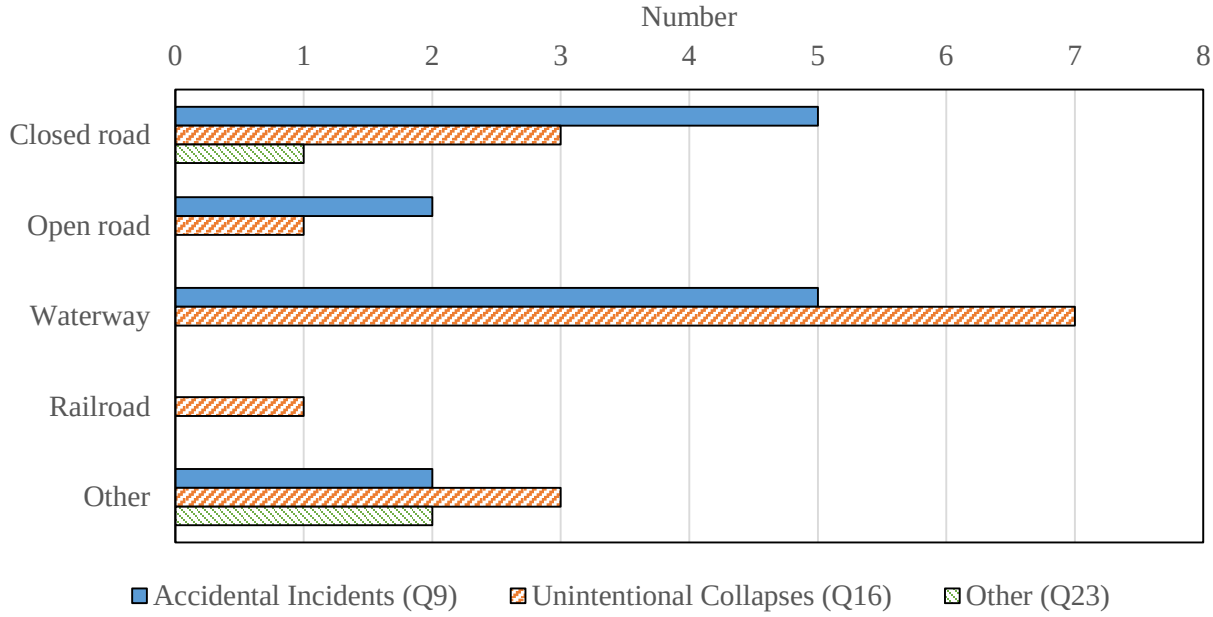


Figure 3.6: Features carried under bridges involved in incidents or collapses

The final question relating to past incidents and collapses was related to the development of post-incident reports. As shown in Figure 3.7, in only one case was a post-incident report developed; no report was developed in all the other cases.

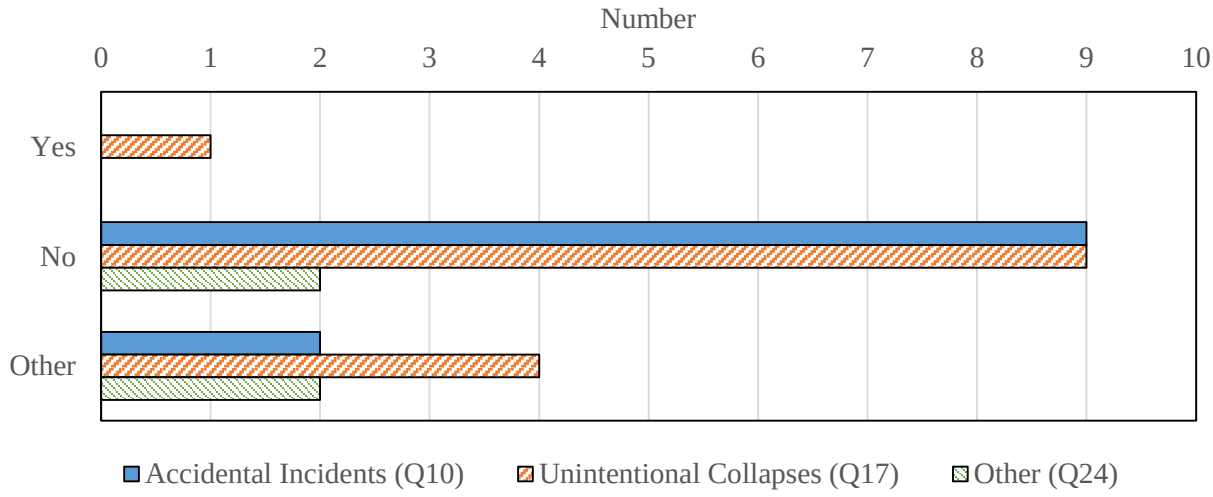


Figure 3.7: Was a post-incident report developed?

3.3. Liability

Twenty seven of the 28 states responded with regard to the questions related to liability. As shown in Figure 3.8 (a), all of the states that responded assign the liability for bridge demolition to the contractor performing the demolition work. With regard to the liability policy, three-quarters (21) of the states who responded believe they have a successful liability policy in place, while about one-quarter (7) of the states do not have any formal liability policy in place.

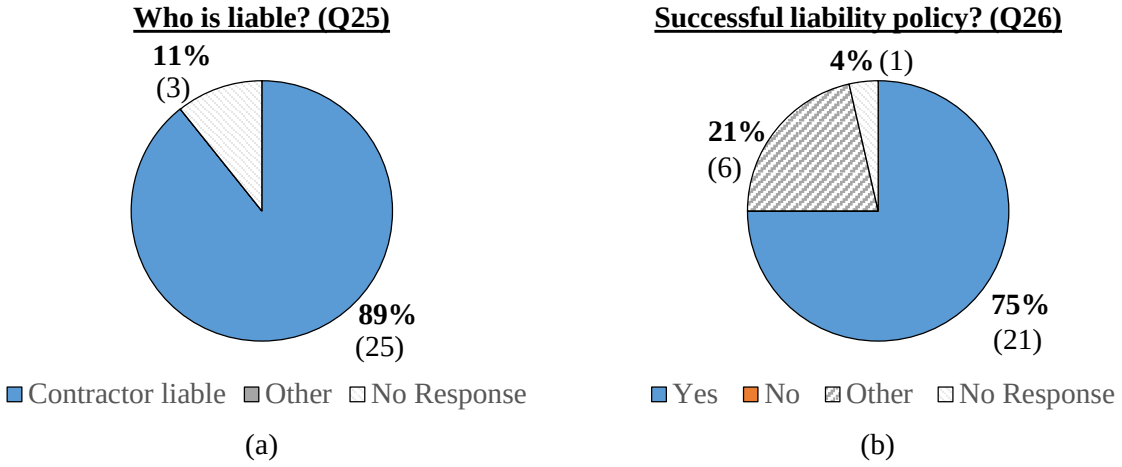


Figure 3.8: (a) Liable party for demolition of bridge (Q25) and (b) answer to whether current liability policies are successful (Q26)

3.4. Requirement of Bridge Demolition Plans

Questions 27 through 33 relate to the demolition plans: when they are required and what they include. Over half (14) of the responding states have no criteria, guidelines, or procedures for when a set of contract plans require the inclusion of a demolition plan, as shown in Figure 3.9.

Out of those with policies, six formal policies were provided: Alabama, California, Illinois, Iowa, Kansas, and Texas. These policies are provided in Appendix A.

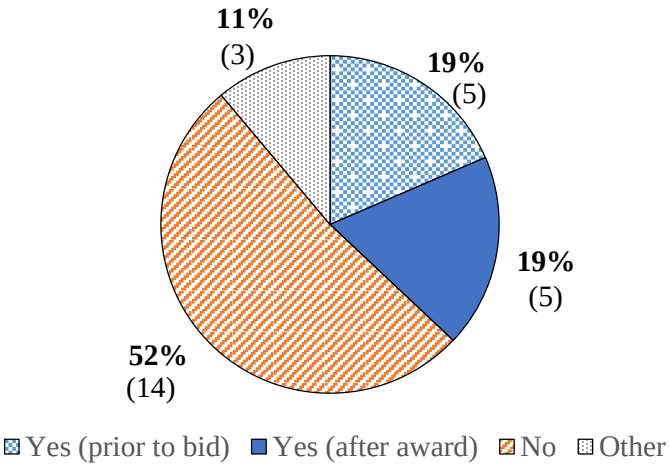


Figure 3.9: Answer to if Agency has criteria, guidelines, or procedures for when a set of contract plans require the inclusion of demolition plan (Q27)

Questions 29 and 30 relate to when a detailed demolition plan is required and the types of associated projects. A detailed demolition plan normally includes a step-by-step procedure for demolition, description of required demolition equipment, any required calculations for full structure or partially demolished structure, and any other general notes or details required. The cases in which detailed demolition plans are required is shown in Figure 3.10 (a) and whether or not contract documents need to include detailed demolition plans is shown in Figure 3.10 (b).

For about half (12) of the responding states (26), detailed demolition documents are required for partial bridge demolition, full bridge demolition, or both partial and full bridge demolition. The other half of the responding states either do not require detailed demolition plans or have other policies. The other responses included that demolition plans are required:

- Only under rare circumstances (2)
- When blasting is used
- For complex projects where public safety is an issue (2)
- Anytime there is a risk
- As specified in the contract documents (2)
- At the discretion of the lead design engineer in consultation with the DOT
- When it effects traffic or railroad

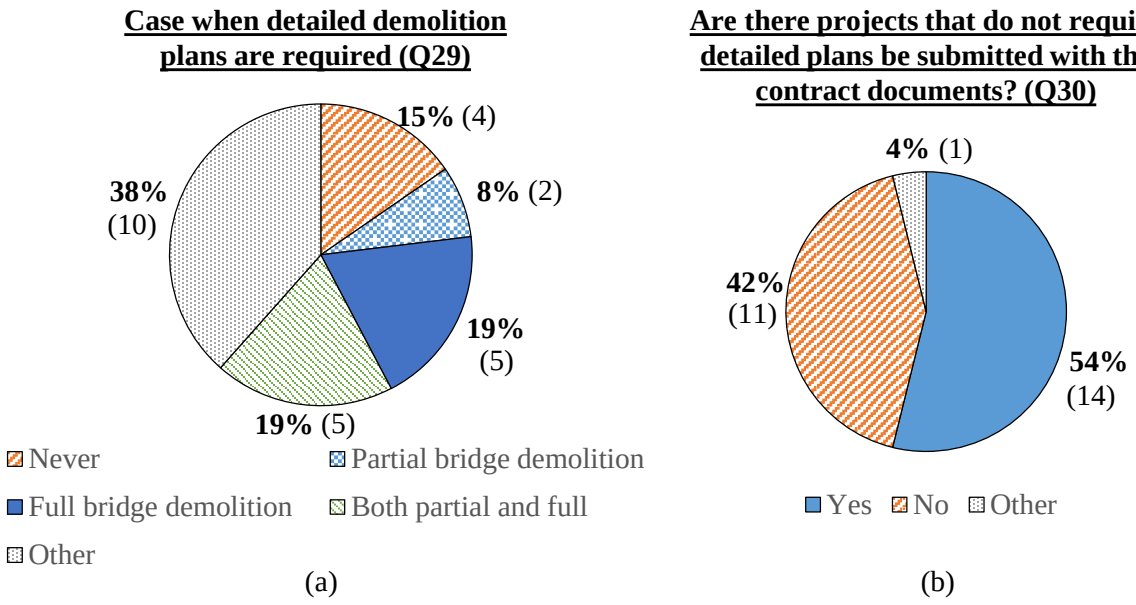


Figure 3.10: (a) Cases when detailed demolition plans are required (Q29) and (b) answer to if there are projects where contract documents do not include detailed demolition plans (Q30)

Further information was gathered for projects not requiring detailed demolition plans. The following are a summary of survey responses with various cases where demolition plans are not required:

- Prestressed girder bridges or concrete slab bridges over low water or channel crossings (when demolition equipment can rest on the ground rather than the bridge)
- Simple projects where public safety is not a risk
- Small structures, short bridges over streams
- Conventional bridge types (i.e. multiple beam bridges)
- Box culvert structures with spans less than 80 feet
- Bridges not being demolished over a public road
- Bridges where adjacent structures are not affected

Alternative delivery methods (e.g. Design/Build, Design/Bid/Build, Detailed Build, P3, CMGC, etc.) are being used more frequently. The next two questions (Questions 31 and 32), shown in Figure 3.11, were looking into how agencies perceive the effect of alternative delivery methods on bridge demolition procedures. As shown in Figure 3.11 (a), about 40-percent of agencies (10 of 26) have criteria and about 40-percent (11 of 26) do not have criteria in which demolition plans are submitted and administered for projects procured under alternative delivery methods. Most of the agencies (about 70-percent) do not see alternative delivery methods as an additional risk (i.e. increased likelihood of accidental incidents and unintentional collapses).

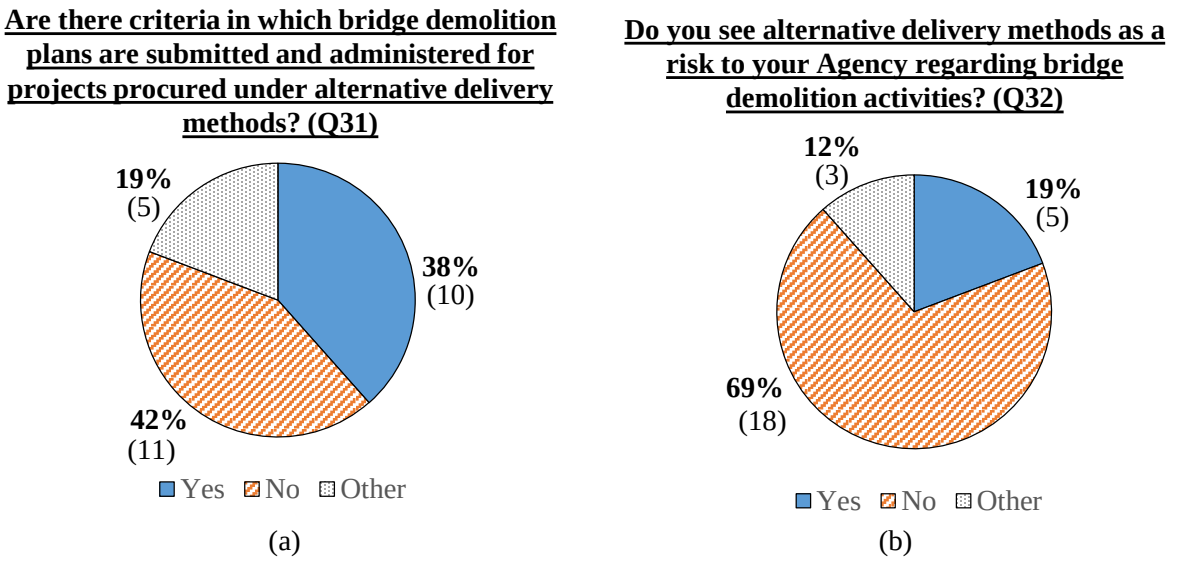


Figure 3.11: Information regarding (a) criteria for bridge demolition (Q31) and (b) perceived risk of alternative delivery methods (Q32)

A small percentage of agencies (11-percent) conduct a risk assessment prior to determining the requirement of bridge demolition plans, as shown in Figure 3.12. The majority of the agencies (85-percent) do not require any kind of risk assessment.

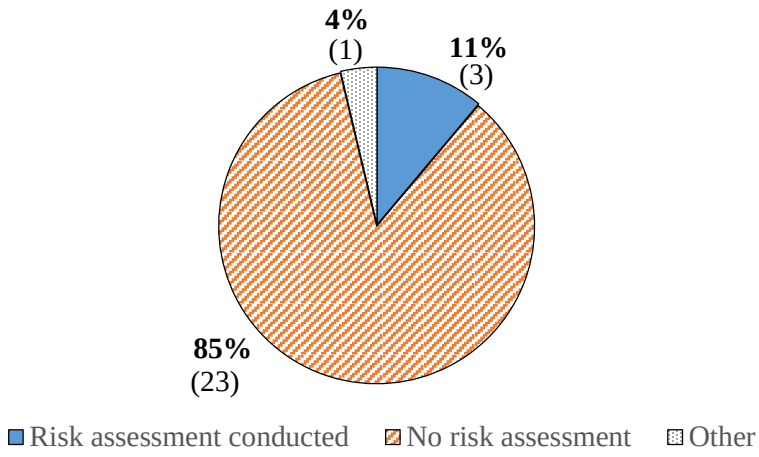


Figure 3.12: Information on whether the Agency conducts a risk assessment before determining demolition plan requirements (Q33)

3.5. Information Required for a Bridge Demolition Submittal

Questions 34 through 41 investigate the general information required for a bridge demolition submission. A design engineer can be required to aid in the development or approval of demolition documents. The frequency of involvement of the design engineer and at what stage the design engineer is required is shown in Figure 3.13 (a) and (b), respectively. Most agencies do not require a design engineer or require the design engineer only for complicated projects. Those that do require a design engineer generally require them to be hired by the contractor.

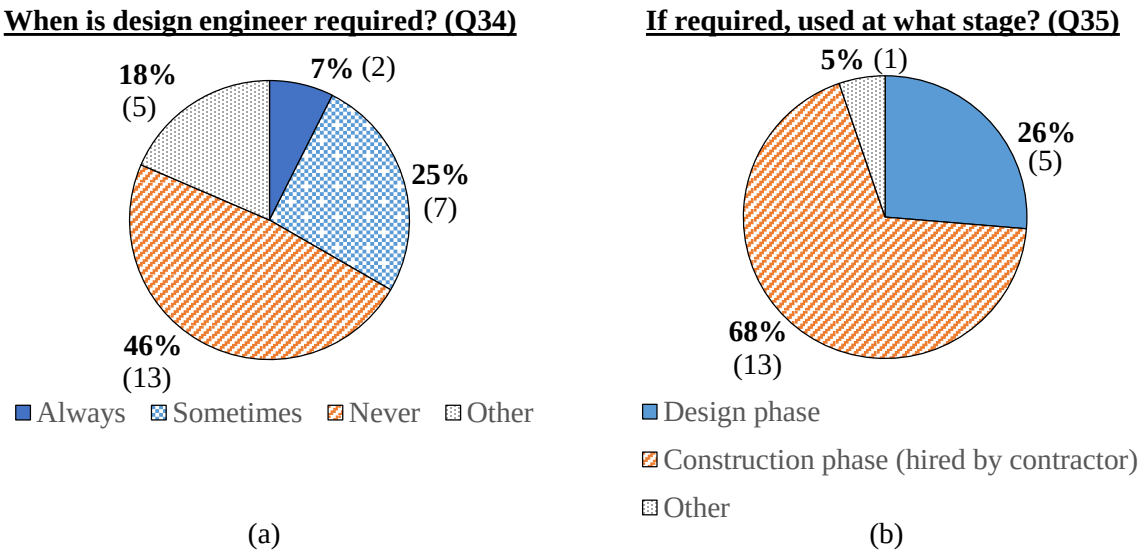


Figure 3.13: Information on (a) need for involvement of design engineer (Q34) and (b) at what stage design engineer is involved (Q35)

Several agencies (16) provided more detailed responses about when design engineers are used in the demolition process. Some of these responses included:

- Design engineers are involved to determine which components of a bridge need to be demolished.
- Contract documents developed by design engineer include a demolition plan only for unique structures like truss, suspension, arch, segmental or other similar bridges.
- Design engineers need to be involved whenever demolition plans are submitted for review and acceptance.
- Design engineers are required for partial demolitions or if the overall stability of the structure is at risk.
- Design engineers are needed when there are any issues with the plans.
- Demolition contractor decides on the need for involvement of a design engineer.
- Contractor's engineer prepares a demolition plan; owner's engineer assists in review of bridges with complex configurations.
- Design engineers are involved in developing demolition-related specifications and requirements and are also involved in the review of the contractor's demolition plans.

Agencies that require the participation of a design engineer require involvement at different stages, as shown in Figure 3.14. Most design engineers are used by the owner to review plans submitted by the contractor. Some states require a design engineer (typically provided by the contractor) be used in preparing demolition plans. Others allow the contractor to decide at what stage the design engineer should be used.

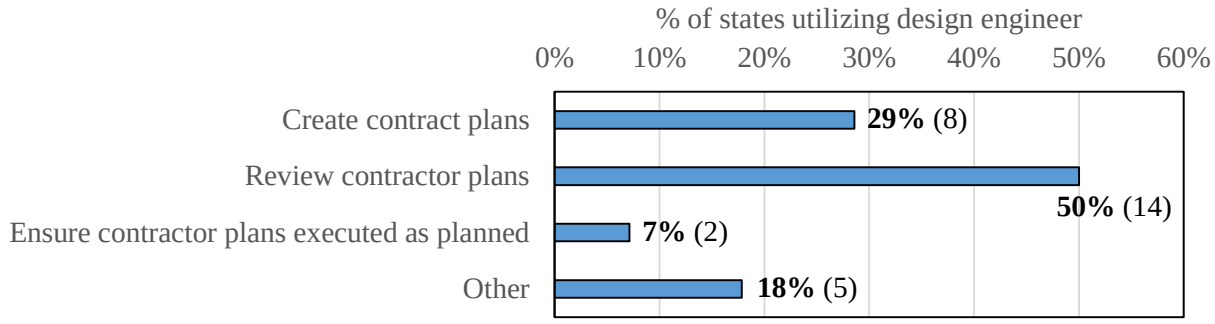
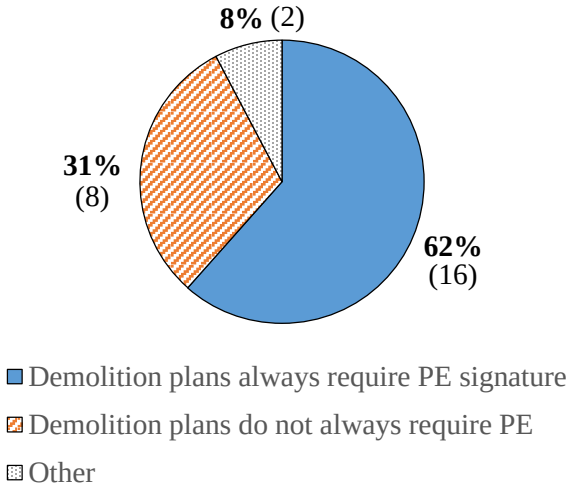


Figure 3.14: Percentage of states requiring design engineer participation in different parts of planning process (Q37)

Even when a design engineer is required on the project, the design engineer is not always required to have a professional engineering (PE) license, as shown in Figure 3.15. Most of the responding agencies always require a PE signature on the final demolition plans. The PE is generally provided by the contractor.



Cases not requiring PE

- Project dependent
- When there is no risk to the public
- When superstructure is not removed
- When no protective cover is required
- For traditional demolitions with no apparent risk for the public and state workers

Figure 3.15: Cases in which a professional engineer involvement is required (Q38 and Q39)

Loading provided from demolition equipment is one of the primary causes for accidental incidents or unintentional collapses. Loading is also variable, as it depends on the specific equipment being used by the contractor on a specific project. Additionally, the condition of the bridge will change as it is being demolished.

Agencies were asked as to whether they specify parameters (e.g. operating ratings, reduced concrete strengths, as-builts, etc.) for demolition equipment. Only a small number of states specify any parameters during the demolition process, as shown in Figure 3.16. About 77-percent of states do not specify any parameters for demolition equipment. Those that do specify some parameters mainly limit the hammer size and energy used for demolition or require an analysis to show that the structure remains stable during all stages of construction.

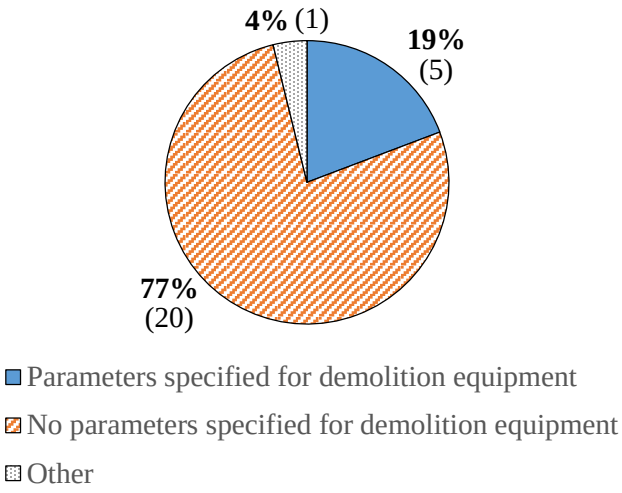


Figure 3.16: Specifying parameters for demolition equipment (Q40)

Numerous events can occur during demolition that result in an accidental incidents and unintentional collapses. Some demolition types are more prone to certain risks, so in some cases agencies will require contingency plans be developed prior to execution of a demolition. The percentage of surveyed agencies requiring contingency plans prior to demolition (as part of the demolition plan submittal) is shown in Figure 3.17.

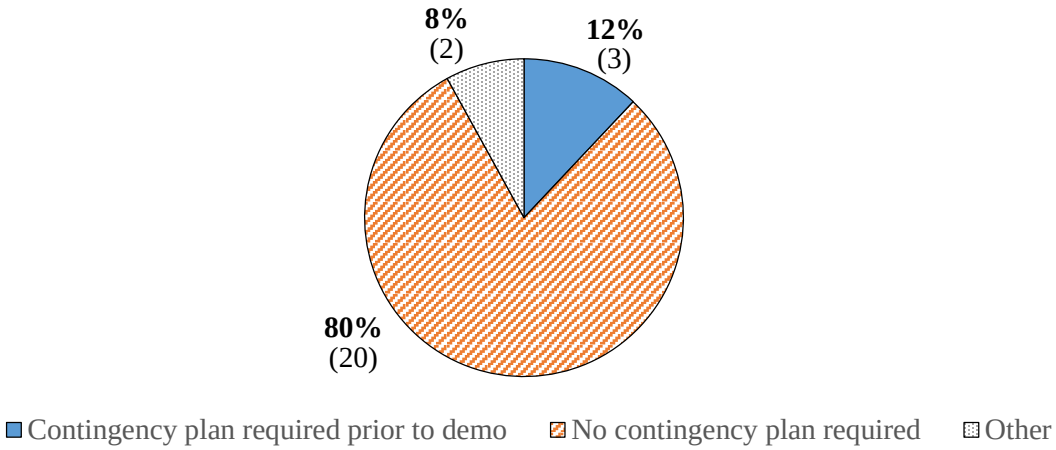


Figure 3.17: Agencies requiring contingency plans prior to demolition (Q41)

The majority of agencies do not require a contingency plan be developed prior to execution of demolition, but most have some mechanism in place for stopping field work and addressing issues as they arise (discussed in later sections). The two cases that may require contingency plan development are (1) repair details for damaged flanges of bulb-T sections during rapid deck demolition projects and (2) plans for addressing equipment failure during demolition.

3.6. Approval of Bridge Demolition Submittal (Prior to Work)

Various levels of approval by the owner are required prior to execution of the demolition plans, as shown in Figure 3.18. The majority of agencies have some form of review system in place

(86-percent). Out of these, 37-percent review bridge demolition plans but do not accept or reject them. Only 38-percent of the surveyed states review and require some level of acceptance or approval of the bridge demolition plans.

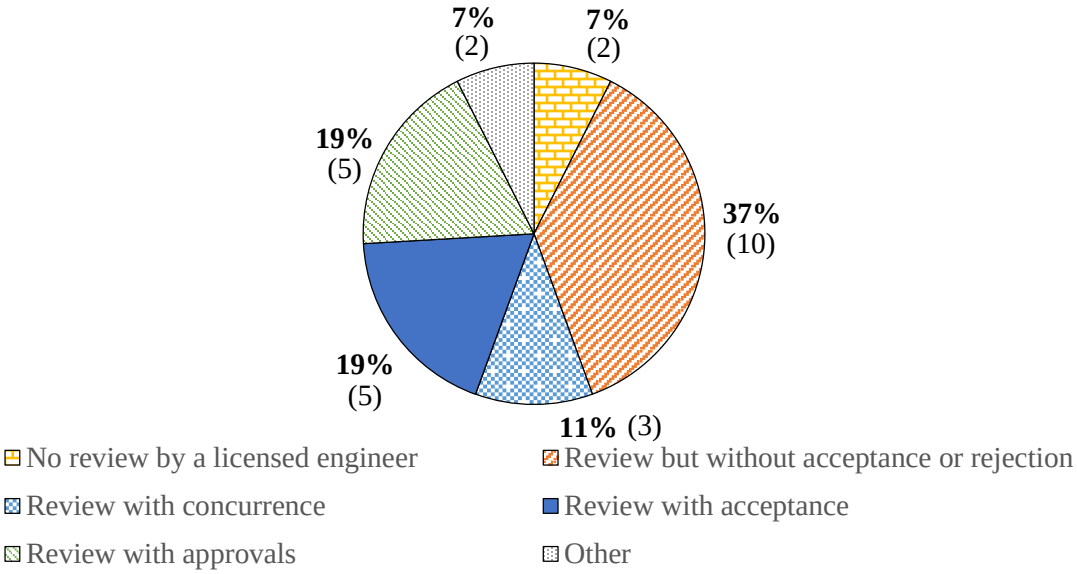


Figure 3.18: Degree of oversight conducted by agency to accept bridge demolition plans (Q42)

Agencies were also asked what wording they use in response to the submitter of the demolition plan if the plan is reviewed and an approval is not given. These responses include:

- "Reviewed"
- "No exception taken"
- "Reviewed for general conformity with plans and specifications for (x)DOT"
- "At your request, we have reviewed demolition sequence. We do not have any objections to the Contractor's proposal. The Contractor and his Engineer shall be fully responsible for the adequacy of the falsework. Any damage shall be repaired to serviceable condition by the Contractor at his expense and to the satisfaction of the Engineer."
- "Project office will share review concerns with contractor (or lack thereof) and work with contractor to address them."
- "Plan is not authorized for the following reasons: …"
- "Received for documentation" or "Not received for documentation"
- "No Exception Taken" or "Make Correction Noted" or "Revise and Resubmit"
- "Submittal is being retained in our records for information only"

Some agencies did not have any standard response wording used in these cases.

3.7. Construction Engineering Inspection and Field Oversight (During Work)

Questions 44 through 52 relate to construction inspection and field oversight. The contractor is responsible for ensuring the demolition plans are executed as planned in about 59-percent of states surveyed, as shown in Figure 3.19. In the remaining states, the proper execution of the

demolition plans is verified by either the bridge owner, engineer of record, field engineer, some combination of these, or there are no specified means.

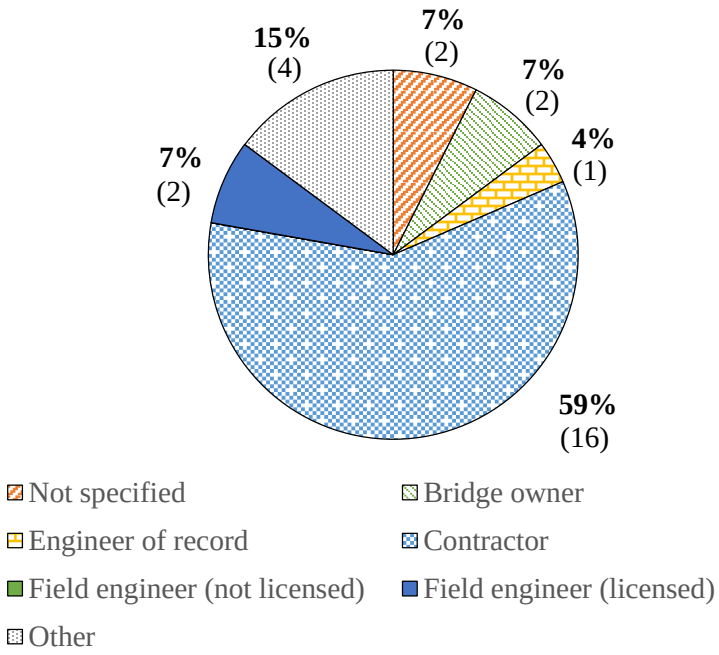


Figure 3.19: Party responsible for ensuring demolition plans executed as planned (Q44)

A pre-demolition meeting is required in some cases to give the contractor and bridge owner an opportunity to discuss details about the demolition. Most bridge owners (47-percent) require no pre-demolition meeting, as shown in Figure 3.20. Only 22-percent of surveyed states require and document a pre-demolition meeting.

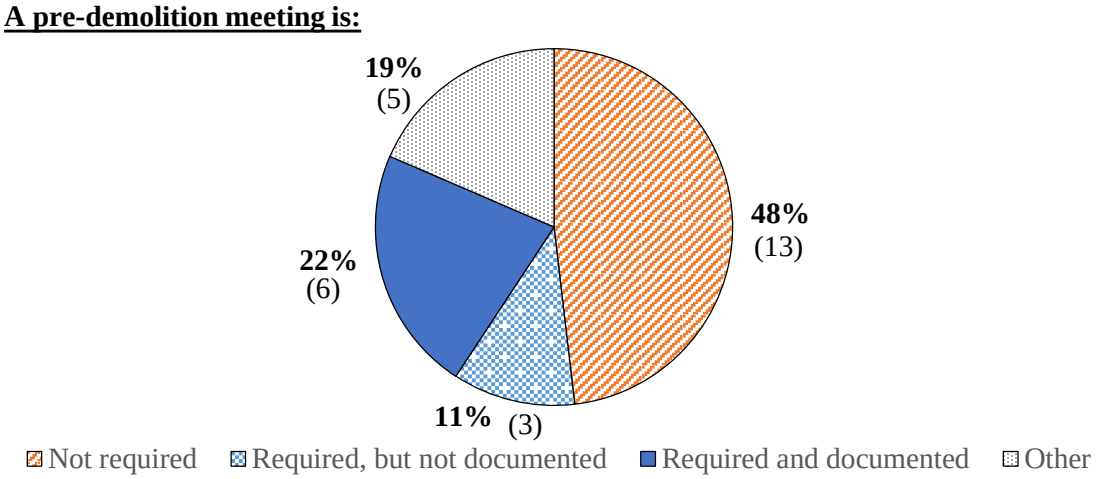


Figure 3.20: Instances when a pre-demolition meeting is required (Q45)

Changes to the initial demolition plan are oftentimes required after the demolition work is already underway. Different agencies have different approval mechanisms in place for these field

changes, as shown in Figure 3.21. Most agencies require field changes be approved by either the bridge owner (31-percent), engineer of record (26-percent), or contractor (14-percent).

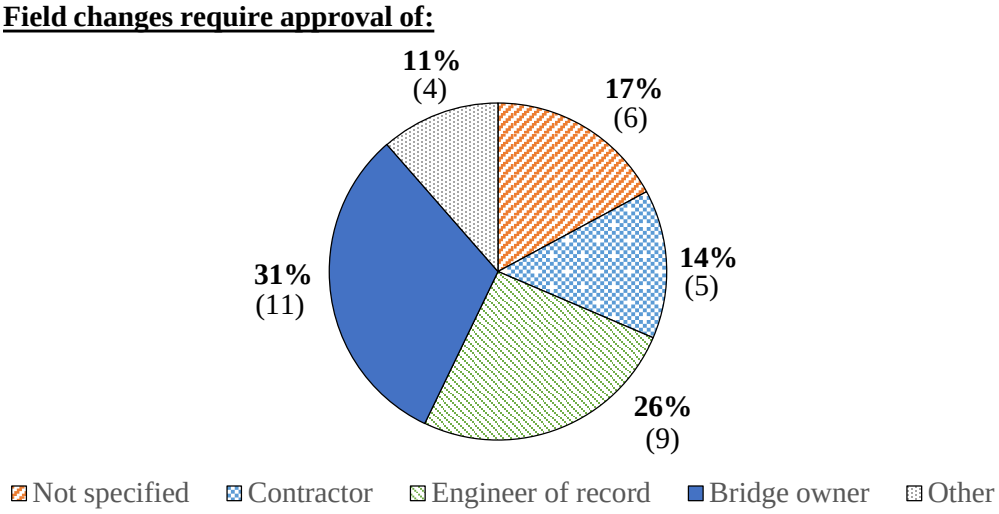


Figure 3.21: Approval requirements for field changes (Q46)

The next question (Q47) relate to mechanisms in place to stop field operations. Most of the surveyed states have a mechanism in place to stop field operations, as shown in Figure 3.22. Those who have a mechanism in place to stop field operations responded as to how they are stopped. Demolitions were mostly stopped by the field inspector, owner, engineer of record, or construction engineer for either safety concerns or for the approved demolition plans not being followed.

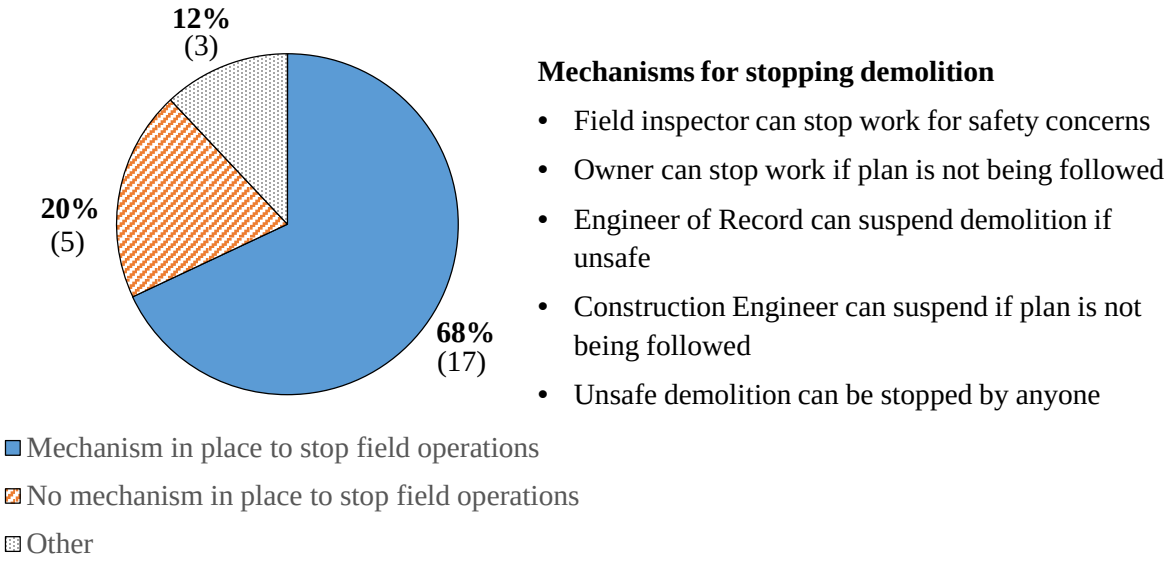
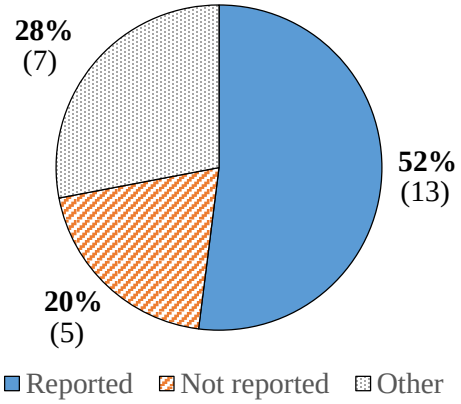


Figure 3.22: Mechanism in place to stop field operations (Q47)

The next question (Q48) asks if accidental incidents and unintentional collapses are reported. About half (52-percent) of the responding states responded that these events are reported. Of

these, incidents were normally reported by the field engineer or through the construction office; other methods for reporting incidents are listed below.

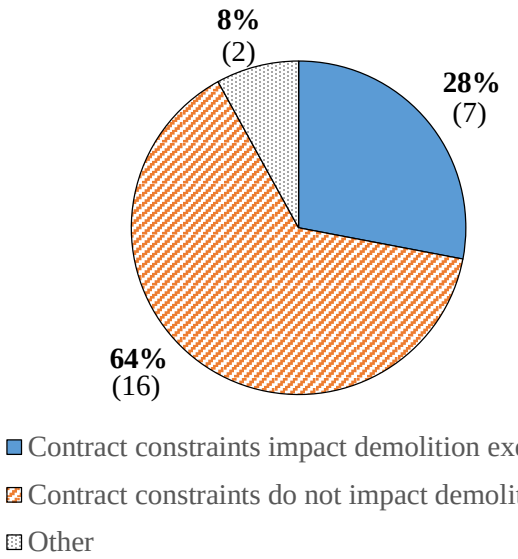


Method for Reporting Incidents

- Field Engineer responsible for reporting
- Reported through construction office
- Direct call to the bridge office
- Incident reported by Resident Engineer
- No official reporting procedure

Figure 3.23: Reporting of accidental incidents and unintentional collapses (Q48)

A perception amongst the bridge community is that contract constraints (e.g. limited work windows/time, nighttime only operations, etc.) impact the manner in which bridge demolition plans are followed. The majority of owners (64-percent) did not perceive contract constraints as an issue, as shown in Figure 3.24. Several responses included comments that constraints are accounted for in the demolition plans.

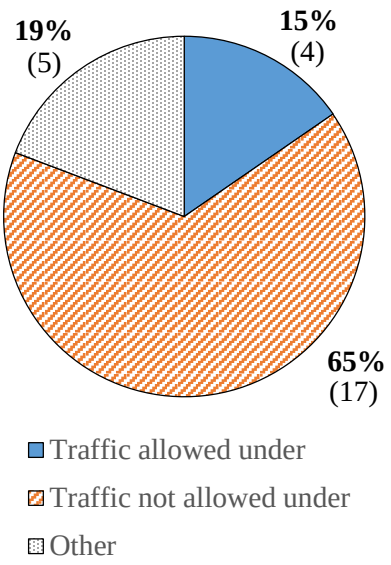


Comments about constraints affecting demolition

- Short durations for removal result in more damage
- Constraints should be accounted for in demolition plans
- Nighttime demolition, limited work times, staged construction/demolition all increase risk
- Working over active rail lines creates tight demolition windows

Figure 3.24: Impact of contract constraints on demolition execution (Q49 and Q50)

As several of the failed demolitions resulted in injury to the public traveling under the bridge, the next question is to determine how many states allow for traffic to pass under active demolition projects. Of the responding states, 65-percent do not allow for traffic to pass under an overpass during demolition, as shown in Figure 3.25. The remaining states either allow traffic under or restrict traffic on a project by project basis. For deck removal, some states allow for traffic to pass beneath as long as a canopy or overhang is constructed to protect traffic from falling debris.



Special protection if traffic is allowed

- Canopy constructed under bridge for deck removal
- Traffic only allowed for deck removal; contractor is held responsible to minimize falling debris
- Bridge overhangs or barriers are constructed to protect traffic

Figure 3.25: Traffic allowance under demolition and protection of traffic (Q51)

The next question in the inspection and field oversight section of the survey (Q52) relates to when specific contractor or personnel qualifications are required to be submitted for owner approval. As shown in Figure 3.26, 40-percent of responding agencies never require the contractor to submit any qualifications. Another 40-percent of states require qualifications be submitted for either complex projects or projects with special safety concerns. Only 8-percent require qualifications be submitted for every project.

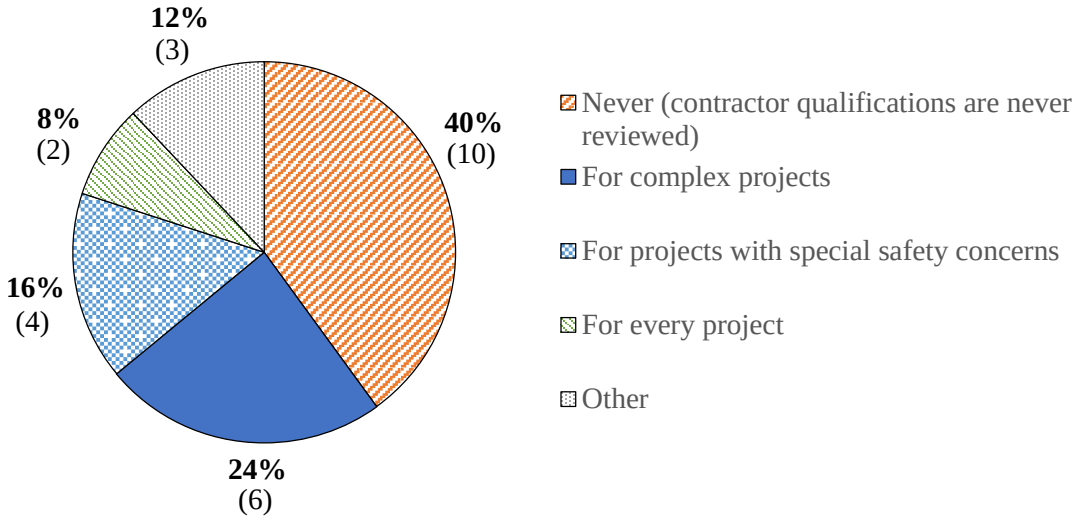


Figure 3.26: Cases when specific contractor qualifications are required to be submitted (Q52)

3.8. Closing Questions

The final questions (Q53 through Q56) are designed to understand what types of documents or resources would be most beneficial to the parties involved. As shown in Figure 3.27, about half

of the surveyed states would find a best practices for bridge demolition execution and/or administration document beneficial. About 70-percent of surveyed states think that a guide specification for bridge demolition would be beneficial.

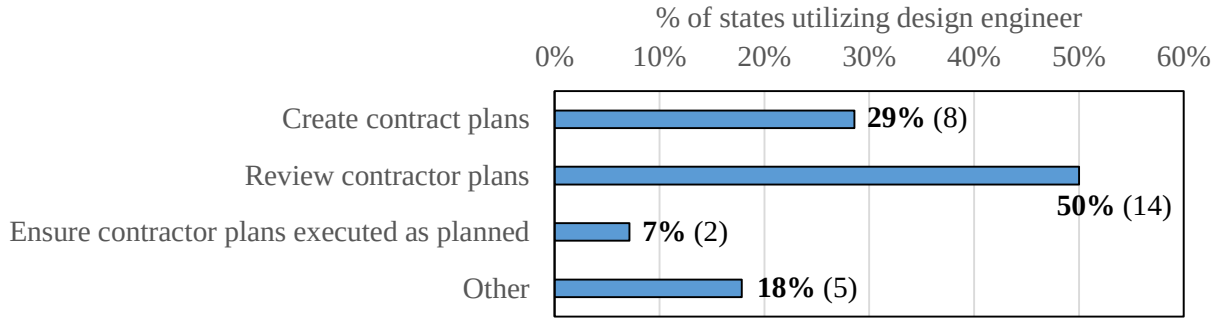


Figure 3.27: Information or resources beneficial for agency (Q53)

CHAPTER 4: EXTRAPOLATED RESULTS

One of the main purposes of this survey was to explore the need for further research related to bridge demolition and the desire from bridge owners for a guide document or specification. This chapter presents an extrapolation of some survey results to gain a national perspective and the opinion of the researcher and several members of the research advisory panel (RAP).

As mentioned, 28 State DOTs (out of 52 possible) responded to the survey. Some of the survey results related to past incidents and collapses have been extrapolated to attempt to see the total national impact. The results from the actual survey were multiplied by three different factors to obtain a range of potential impacts, as shown in Table 4.1. This range is simply to give a ±10 percent interval. Additionally, the states were asked to respond with the number of events that occurred in the past 15 years. Rate per year estimates were obtained by dividing the national perspective estimate by 15 years.

Table 4.1: National perspective factors used to extrapolate survey results to national scale

Factor	Value
Low Factor	$0.9\left(\frac{n_{total}}{n_{response}}\right) = 1.67$
Medium Factor	$\left(\frac{n_{total}}{n_{response}}\right) = \left(\frac{52}{28}\right) = 1.86$
High Factor	$1.1\left(\frac{n_{total}}{n_{response}}\right) = 2.04$

The first extrapolation is for the total number of accidental incidents, unintentional collapses, and other incidents, shown in Table 4.2. If the number of actual observations is extended to a national perspective, it can be seen that there are about two accidental incidents and two unintentional collapses per year.

Table 4.2: Estimates for national total of accidental incidents, unintentional collapses, and other events

		National Perspective Estimate			Rate Per Year Estimate		
	Actual	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
No. of Acc. Incidents	16	27	30	33	1.8	2.0	2.2
No. of Unin. Collapses	16	27	30	33	1.8	2.0	2.2
No. of Other	1	2	2	2	0.1	0.1	0.1
Totals	33	56	62	68	3.7	4.1	4.5

The number of injuries and fatalities that have resulted from the reported accidental incidents and unintentional incidents are extrapolated to gain a national perspective in Table 4.3 and Table 4.4, respectively. It can be seen that around 1.5 injuries and 0.6 fatalities occur per year as a result

from failed demolition events. It should be noted that these numbers are only from the events that were reported to or observed by the bridge owners.

Table 4.3: Estimate for national total of injuries caused by accidental incidents, unintentional collapses, and other events

		National Perspective Est.			Rate Per Year Estimate		
Number of injuries during:	***Actual***	***Low***	***Medium***	***High***	***Low***	***Medium***	***High***
Accidental Incidents	3	5	6	6	0.3	0.4	0.4
Unintentional Collapses	9	15	17	18	1.0	1.1	1.2
Other Incident	0	0	0	0	0.0	0.0	0.0
Totals	12	20	23	24	1.3	1.5	1.6

Table 4.4: Estimate for national total of fatalities caused by accidental incidents, unintentional collapses, and other events

		National Perspective Est.			Rate Per Year Estimate		
Number of fatalities during:	***Actual***	***Low***	***Medium***	***High***	***Low***	***Medium***	***High***
Accidental Incidents	2	3	4	4	0.2	0.2	0.3
Unintentional Collapses	3	5	6	6	0.3	0.4	0.4
Other Incident	0	0	0	0	0.0	0.0	0.0
Totals	5	8	10	10	0.5	0.6	0.7

In summary, from a national perspective, the approximately 27 to 33 accidental incidents and approximately 27 to 33 unintentional collapses that occurred over the past 15 years have resulted in about 20 to 24 injuries and 8 to 10 fatalities (as a low estimate). This is less than about two injuries per year and less than one fatality per year due to bridge demolition related activities.

It should be highlighted that these survey results are limited to representing the Owner's feedback only. As demonstrated by this survey, there is a notable disconnect between bridge owners and demolition contractors. From discussions with RAP members who are or are in close contact with demolition contractors, the number of accidental incidents, unintentional collapses, and related injuries and fatalities are likely three times or more the number shown in the above extrapolations. Most incidents are not reported by the contractor to the owner. The actual number of these events and related injuries and fatalities would be attainable from the contractors and insurance companies where claims are made by those injured or families of those killed. If a more accurate number of injuries and fatalities is desired, the contractors and insurance companies should be surveyed.

CHAPTER 5: SUMMARY

The summary and conclusions will correspond to the eight different sections of the survey.

5.1. Background Questions

In total, 28 agencies responded to the demolition survey; all of the agencies were state DOTs.

5.2. Past Accidental Incidents and Unintentional Collapses

A quarter of responding states have experienced an accidental incident and 43-percent have experienced an unintentional collapse in the past 15 years. These proportions show that problems with bridge demolitions are not isolated to only a few states.

Of the incidents that occurred, the majority occurred during conventional construction projects or rehabilitation and repair projects. Only one accidental incident and one unintentional collapse occurred during bridge projects with any accelerated construction technique.

The majority of incidents occurred on bridges either over closed roadways or waterways. Two accidental incidents and one unintentional collapse occurred over a roadway open to the public.

About one-quarter of the accidental incidents that occurred resulted in injury or loss of life, while about half of the unintentional collapses resulted in injury or loss of life. Of these, most of the injuries were to contractor employees.

A post-incident report was only developed for only one out of 28 incidents.

5.3. Liability

All responding states hold the contractor liable for the bridge demolition work and about three quarters of them viewed this policy as being successful. There was no information gathered in the survey related to whether any owners have been held liable in any failed demolitions.

5.4. Requirements of Bridge Demolition Plans

Only 38-percent of responding states have criteria, guidelines, or procedures for when a set of contract plans require the inclusion of a demolition plan. Demolition plans are oftentimes not required for simple projects where the public safety is not at risk. Over 50-percent of responding states have projects that do not require detailed demolition plans to be submitted.

Many states (38-percent of responding states) have criteria for submitting demolition plans for projects procured under alternative delivery methods (e.g. Design/Build, Design/Bid/Build, Detailed Build, P3, CMGC, etc.). The majority of responding states (69-percent) do not see alternative delivery methods posing an additional risk.

Only a small percentage of states (11-percent) conduct a risk assessment prior to determining the requirement for bridge demolition plans.

5.5. Information Required for a Bridge Demolition Submittal

Only 33-percent of responding states either sometimes require a design engineer (26-percent) or always require a design engineer (7-percent) in the development of demolition plans. Those states that do require a design engineer generally require them in the construction phase to either create or review the contract plans and require the design engineer be hired by the contractor. If a state's use of design engineer is case dependent, the design engineer is often required when only

a component of the bridge is to be demolished, for staged demolitions, or when the overall stability of the structure during demolition is in question.

A professional engineer (PE) is required by 16 of the responding states to sign the demolition plans (compared to the 22 responding states who require detailed demolition plans be submitted for all or some projects).

The majority of responding states (77-percent) do not specify any parameters for demolition equipment.

The majority of responding states (80-percent) do not require any contingency plans be developed prior to demolition. Those that do either require plans for repairing flanges in deck demolition projects or require plans for alternate demolition equipment.

5.6. Approval of Bridge Demolition Submittal (Prior to Work)

The majority of responding states (86-percent) have some review process in place for the demolition plans. Many of these states (37-percent) review the plans but without acceptance or rejection.

5.7. Construction Engineering Inspection and Field Oversight (During Work)

The majority of responding states (59-percent) assign the contractor as the party responsible for ensuring demolition plans are executed as planned. The remainder of responding states assign this responsibility to the bridge owner (7-percent), engineer of record (4-percent), field engineer (7-percent), or they do not specify a responsible party (7-percent).

Most states either do not require a pre-demolition meeting (48-percent) or require but do not document (11-percent). Only 22-percent of responding states require and document a pre-demolition meeting.

In 31-percent of the 28 responding states, any field changes require the approval of the bridge owner. Other responding states require field changes be approved by the engineer of record (26-percent), contractor (14-percent), or do not specify an approver (17-percent).

The majority of responding states (68-percent) have a mechanism in place for stopping bridge demolition. Some mechanisms include: a field inspector is assigned to stop work for safety concerns; owners or the engineer of record can suspend work if a plan is not being followed; and unsafe demolitions can be stopped by anyone. Twenty-percent (5) of the 25 states who responded to this question have no mechanism in place to stop field operations.

When incidents do occur, 52-percent of responding states claimed to have a reporting mechanism in place to communicate them between contractor and owner. Incidents could be reported by the field engineer, through the construction or bridge office, or by the resident engineer.

The majority of responding states (64-percent) do not view contract constraints as affecting demolition execution, as constraints are normally accounted for in the demolition plans.

The majority of responding states (65-percent) do not allow traffic under demolition projects. Those that do generally only do for deck removal and require a canopy be provided to catch falling debris.

Most responding states (40-percent) never require the submission of contractor qualifications with the demolition plans. Those that do require contractor qualifications be submitted mostly

require submission for complex projects (24-percent) or projects with special safety concerns (16-percent).

5.8. Closing Questions

Most states would find the following documents beneficial:

- Best Practices for Bridge Demolition Execution (48-percent)
- Best Practices for Bridge Demolition Administration (52-percent)
- Guide Specification for Bridge Demolition (69-percent)

5.9. Conclusions and Future Work

Bridge demolition administration is owner dependent. Some states have successful, formal policies for bridge demolition administration; however, the majority of states do not have any formal policy or have experienced accidental incidents or unintentional collapses in the recent past. The bridge community would greatly benefit from a further exploration of bridge demolition practices and the development of a best practices document or specification.

Future work is recommended in several areas:

1. Some type of guide specification or best practices guide is needed to ensure more consistent demolition practices and administration on a national scale.
2. A better understanding of demolition-related loading is needed.
3. A method for analyzing the stability of bridges during demolition is needed, especially for continuous structures during full demolition and composite structures during deck demolition.

This work may be undertaken during later phases of this project.

REFERENCES

[1] American Association of State Highway and Transportation Officials (AASHTO), "AASHTO LRFD Bridge Design Specification, Customary U.S. Units, 6th Edition," Washington, D. C.2012.

[2] D. Downey and B. Rokos, "State: Death in 91 bridge collapse was result of safety violations," in *Orange County Register*, ed, 2014.

[3] H. Molski, K. Perry, P. Brennan, and J. Williams, "Man killed by I-75 bridge collapse," in *Cincinnati Enquirer*, ed, 2015.

APPENDIX A: STATE DOT DEMOLITION STANDARDS

A.1. Alabama DOT

ALABAMA DEPARTMENT OF TRANSPORTATION

DATE: April 20, 2012 Special Provision No. 12-0282

EFFECTIVE DATE: September 1, 2012

SUBJECT: Bridge Removal.

Alabama Standard Specifications, 2012 Edition, SECTION 206 shall be revised as follows:

SECTION 206
REMOVAL OF MISCELLANEOUS EXISTING DRAINAGE AND OTHER FACILITIES

206.03 Construction Requirements.

This article shall be revised by adding the following paragraph thereto:

Each existing bridge or portion thereof requires a removal plan to be submitted to the Construction Bureau prior to starting demolition. No demolition work can start until the removal plan has been accepted and distributed.

A.2. CalTrans

SECTION 60 **EXISTING STRUCTURES**

60-2.02 BRIDGE REMOVAL

60-2.02A General

60-2.02A(1) Summary

Section 60-2.02 includes specifications for removing bridges or portions of bridges.

60-2.02A(2) Definitions

Reserved

60-2.02A(3) Submittals

If a daily inspection report is required, submit the daily inspection report as an informational submittal.

Submit a bridge removal work plan for each bridge. Include details for the following:

1. Removal sequence, including staging of removal activities and equipment locations
2. Temporary support shoring or bracing
3. Locations where work is performed over traffic, utilities, or railroad property
4. Locations and types of protective covers
5. Protection of people, property, utilities, and improvements
6. Methods for preventing material, equipment, and debris from falling onto traffic or railroad property

If protective covers are required or superstructure removal work is performed, bridge removal work plans must be (1) accompanied by substantiating calculations and (2) signed by an engineer who is registered as a civil engineer in the State.

Calculations for bridge removal work plans must demonstrate the stability of the structure during each stage of removal and must include dead and live loads used in the design of the protective covers. A stage is removal of (1) the deck, soffit, or girders in any span; or (2) walls, bent caps, or columns at support locations.

If an unplanned event occurs or the removal activities deviate from the authorized work plan, immediately submit procedures proposed to correct or remedy this occurrence. The procedures must be signed by an engineer who is registered as a civil engineer in the State.

Allow 20 days for review of the bridge removal work plan.

60-2.02A(4) Quality Assurance

60-2.02A(4)(a) General

Reserved

60-2.02A(4)(b) Quality Control

For bridge removal work plans signed by a registered engineer, the engineer signing the work plan must:

1. Be present at all times during bridge removal activities.
2. Prepare a daily inspection report for removal activities. The daily inspection report must describe work activities for each day and the condition of the remaining structure. A copy of the report must be available at the job site at all times.

60-2.02B Materials

60-2.02B(1) General

Reserved

60-2.02B(2) Design Criteria for Temporary Support Shoring and Temporary Bracing

The horizontal load to be resisted in any direction for temporary support shoring and temporary bracing must be (1) the sum of actual horizontal loads due to equipment, construction sequence, or other causes plus an allowance for wind and (2) not less than 5 percent of the total dead load of the structure being removed.

60-2.02C Construction

60-2.02C(1) General

The Engineer may require you to perform additional exploratory work of bridge members for unforeseen damage. This work is change order work.

You may use flame and saw cutting for removing, widening, or modifying bridges.

If complete bridges are removed, do not start removal activities until traffic is no longer carried on the bridge.

For bridge removal activities over or adjacent to roadways that are only closed to traffic when removal work is being performed:

1. Have all necessary personnel, materials, and equipment to complete the work onsite before closing the roadway. Perform activities without interruption until the roadway is reopened.
2. Perform bridge removal activities only when the roadway is closed to traffic except as specified for preliminary work.
3. During roadway closures, debris from bridge removal activities may fall directly onto the roadway if protection is furnished for highway facilities. Minimum protection for paved areas is a 2-foot-thick earthen pad or a 1-inch-thick steel plate placed over the impact area. Before reopening the roadway, all debris, protective pads, and devices must be removed and the roadway swept clean with wet power sweepers or equivalent methods.
4. For girder bridges, completely remove each girder within a span before starting removal of the adjacent girder.
5. For slab bridges, perform removal activities within a span along a front parallel with the primary reinforcing steel.

Temporary support shoring, temporary bracing, and protective covers must not encroach within 8 feet horizontally or 15 feet vertically of traffic lanes or shoulders open to traffic.

Temporary support shoring, temporary bracing, and protective covers over railroad property must (1) conform to guidelines of the railroad company involved and (2) provide the minimum clearances specified for railroad traffic.

60-2.02C(2) Protective Covers

Provide protective covers for removal work over traffic or railroad property. Protective covers must:

1. Be constructed before starting removal activities.
2. Prevent any materials, equipment, or debris from falling onto traffic or railroad property.
3. Be supported using shoring, falsework, or the existing structure.
4. Provide the openings specified in section 12-4. If no openings are specified for removal work, provide a vertical opening of 15 feet and a horizontal opening of 32 feet for traffic.
5. Be cleaned of debris and fines before being removed.

At locations where only bridge railing is removed, protective covers must extend from the face of the exterior girder or at least 2 feet inside of the railing to be removed to at least 4 feet beyond the outside face of the railing.

At locations where entire girders are removed, protective covers must extend at least 10 feet beyond the outside face of the bridge railing.

A separate protective cover is not required during removal of bridge segments if portions of the bridge satisfy the requirements for protective covers.

60-2.02C(3) Preliminary Work

Preliminary work is limited to activities that (1) will not reduce the structural strength or stability of the bridge or bridge elements to a hazardous level as determined by the Engineer or (2) do not cause debris or any other material to fall onto the roadway.

You may perform preliminary work if you use protective covers. Protective covers must:

1. Support all loads

2. Prevent dust and fine material from falling onto the traveled way
3. Extend at least 4 feet beyond the limit of the work being performed.

Bottom slabs of box girders may be considered as protective covers for preliminary work performed on top slabs inside the limits of the exterior girders.

Use temporary support shoring and bracing during preliminary work if needed to ensure the stability of the bridge.

60-2.02D Payment

Not Used

60-2.03–60-2.10 RESERVED

60-3 STRUCTURE REHABILITATION

60-3.01 GENERAL

60-3.01A General

Section 60-3 includes specifications for rehabilitating structures.

60-3.01B Materials

Not Used

60-3.01C Construction

Not Used

60-3.01D Payment

Not Used

60-3.02 BRIDGE DECK REPAIR AND PREPARATION

60-3.02A General

Section 60-3.02 includes specifications for (1) repairing concrete deck surfaces and (2) preparing concrete deck surfaces to receive an overlay or a deck treatment.

60-3.02B Materials

60-3.02B(1) General

Reserved

60-3.02B(2) Rapid Setting Concrete

Rapid setting concrete must comply with the specifications for bonding materials in section 51-1.02C.

You may extend rapid setting concrete using a clean, uniform, and rounded aggregate filler with a moisture content of no more than 0.5 percent. Aggregate gradation must comply with the requirements shown in the following table:

Sieve size	Percentage passing
1/2"	100
No. 16	0–5

The amount of aggregate filler must comply with the manufacturer's instructions. Concrete strengths for extended concrete must be at least as specified for magnesium phosphate concrete.

Combine components of dual-component magnesium phosphate by mixing only complete units supplied by the manufacturer. Do not add water to dual-component magnesium phosphate.

60-3.02C Construction

60-3.02C(1) General

Before starting deck rehabilitation activities, complete the removal of any traffic stripes, pavement markings, and pavement markers.

A.3. Illinois DOT

DIVISION 500. STRUCTURES

BRIDGES

SECTION 501. REMOVAL OF EXISTING STRUCTURES

501.01 Description. This work shall consist of the removal of existing traffic and drainage structures or portions thereof.

CONSTRUCTION REQUIREMENTS

501.02 General. The Contractor shall submit a demolition plan to the Engineer for approval, including the proposed methods of demolition and the location(s) and type(s) of equipment to be used, for the removal of existing bridge structures or bridge decks (with the exception of box culverts), when such work will be adjacent to or over an active roadway, railroad, or waterway designated on the plans as "Public Waters". The demolition plan shall include an assessment of the structure condition and an evaluation of the capacity and stability of the structure during demolition and shall be sealed by an Illinois Licensed Structural Engineer.

Materials that are to be salvaged under the contract and which the Engineer deems fit for reuse shall be carefully removed in transportable sections and stockpiled near the site at a location designated by the Engineer. If the material for reuse is unfit, through no fault of the Contractor, the material shall be disposed of according to Article 202.03. When the Contractor damages or destroys such material, the Contractor shall repair or replace the material in a manner satisfactory to the Engineer. Materials that are not to be salvaged shall be removed and disposed of according to Article 202.03.

When a superstructure is specified to be salvaged for reerection, all members and loose parts shall be properly matchmarked, all machined steel surfaces treated with an approved anti-rust compound, and all loose parts wired to adjacent members or packed in marked boxes.

501.03 Protective Shield System. When required, a protective shield system shall be erected and maintained to protect pedestrian, vehicular, or railroad traffic from falling objects. The system shall protect the bridge length shown on the plans. The width to be protected shall be the out-to-out width of the existing structure, unless otherwise shown on the plans. The protective shield system shall be designed and constructed to sustain loads of 200 lb/sq ft (9.5 kPa) in addition to its own weight. Protective shield systems comprised of wood members shall be designed for a minimum loading duration of seven days. The system may be either fixed or mobile. The existing vertical clearances above roadways and/or railroad tracks shall be maintained. The Contractor shall coordinate the installation with municipalities and/or utilities to ensure protection of their facilities during the removal process.

The Contractor shall submit working drawings and calculations prepared and sealed by an Illinois Licensed Structural Engineer to the Engineer for the protective shield system. The drawings shall provide full details, dimensions, and types of

materials proposed for use. The protective shield system shall not be installed until authorization to proceed is given by the Engineer.

Concrete removal shall not commence until the protective shield system is in place and in conformity with the sealed working drawings.

Upon completion of the work or when directed by the Engineer, the protective shield system shall be removed.

501.04 Complete Removal of Structures. Existing structures shall be removed to at least 1 ft (300 mm) below the proposed elevation of subgrade or ground surface. Portions of existing structures below this elevation that interfere with the proposed construction shall also be removed.

When slope wall is specified to be removed, it shall be the responsibility of the Contractor to determine the thickness of the slope wall to be removed and the extent to which it is reinforced. No additional compensation will be allowed because of variations from the assumed thickness or from the thickness shown on the plans, or for variations in the amount of reinforcement.

Removal of existing pipe culverts shall include any headwalls, wingwalls, or aprons attached to the culvert.

501.05 Partial Removal of Structures. Where portions of existing structures are to remain in service, portions to be removed shall be removed in such a manner as to leave the remaining structure undamaged and in proper condition for the use contemplated. Any damage to the portions remaining in service shall be repaired. Repairs shall be made as directed by the Engineer. The removed portions shall be disposed of according to Article 202.03.

Prior to partial removal of any concrete structure, a 3/4 in. (20 mm) deep saw cut shall be made along all boundaries of removal areas adjacent to areas to remain in place.

Where existing bars are to extend from the remaining portions of existing structures into new construction, the concrete shall be removed so as to leave the projecting bars clean and undamaged. All newly exposed concrete and exposed reinforcement bars to be incorporated into new concrete shall be blast-cleaned; epoxy coated reinforcement bars shall be cleaned and repaired according to Article 508.04. Where projecting bars are not to extend into the new construction, they shall be cut off flush with the surface to which the old concrete has been removed.

Additional requirements for the partial removal of specific structures shall be as follows.

(a) Bridge Decks, Partial Removal. When utilizing hammers to perform partial removal within 1 ft (300 mm) of the saw cut boundaries or portions of the existing bridge deck to remain in service, the hammers shall be limited to 15 lb (7 kg) chipping hammers or hand tools. Particular care shall be exercised at the bottom of the slab to avoid breakage beyond the designated removal line. When jack hammers are utilized to remove the remaining

concrete, the hammers shall not be heavier than the nominal 45 lb (20 kg) class. More powerful hydraulic impact equipment will not be allowed to perform this removal. The surfaces presented as a result of this removal shall be reasonably true and even, with sharp straight corners that will permit a neat and workmanlike joint with the new construction.

Upon removal of the formwork, the bottom surfaces of new concrete, adjacent to remaining portions of existing concrete, shall be inspected with hammer sounding to detect loose and delaminated areas. Those areas shall be removed as directed by the Engineer. All removed areas 1 in. (25 mm) or deeper shall be repaired with an approved method.

(b) Bridge Decks, Complete Removal. The concrete within 1 ft (300 mm) of partial depth saw cut boundaries, stage removal lines, or attached to and/or supported by portions of the structure to remain in service shall be removed according to Article 501.05(a). When jackhammers or hydraulic impact equipment are utilized to remove the remainder of the concrete, the equipment shall have a maximum rated striking energy of 1200 ft lb (1600 J). When saw cutting of the deck is utilized for deck removal, the top flanges of all beams or girders shall be marked on the deck surface. Saw cutting directly over the top of beam or girder flanges may be permitted only if shown on the plans. The maximum saw cut depth allowed directly over a flange shall be to the bottom of the top mat of reinforcing steel but shall not exceed half the deck thickness. The Contractor shall provide positive control for controlling the depth of cut into the slab. The Contractor shall provide sawing equipment adequate in size and horsepower to complete the sawing operation.

(c) Culverts. At locations designated by the Engineer, all earth and debris shall be removed from the invert of the portions of existing culverts which are to remain in service.

(d) Substructures. When piers, abutments, or retaining walls, etc. or portions thereof are to be removed adjacent to structures or property to remain in use, even if that use is only temporary, the removal shall be done in such a manner as to not transmit damaging energy in to the remaining structure. The maximum rated impact energy shall be limited to 1200 ft lb (1600 J) unless the remaining portion of the structure can be fully isolated from the portion being removed. The removal shall be completed so as to maintain adequate structural and foundation support of the remaining elements.

At the Contractor's option, hydrodemolition equipment meeting the requirements of Article 1101.11 may be used. Operation of the hydrodemolition equipment shall be performed and supervised by qualified personnel certified by the equipment manufacturer. Evidence of certification shall be presented to the Engineer. When partial-depth removal is required, the equipment shall be calibrated and set to remove sound concrete to the required depth. If sound concrete is being removed below the required depth, the Engineer will require the equipment to be recalibrated and reset.

The Contractor shall control the runoff water generated by the various construction activities in such a manner as to minimize, to the maximum extent practicable, the discharge of construction debris into adjacent waters, and shall

properly dispose of the solids generated according to Article 202.03. Runoff water shall not be allowed to constitute a hazard on adjacent or underlying roadways, waterways, drainage areas, or railroads, nor be allowed to erode existing slopes.

501.06 Method of Measurement. When paid for as a separate item, removal of existing structures, removal of existing superstructures, removal of existing concrete deck, and removal of existing concrete headwall for pipe culverts will be measured for payment in units of each at the location designated on the plans.

The protective shield system will be measured for payment in place and the area computed in square yards (square meters). The length will be measured along the centerline of the structure. The width will be measured perpendicular to the centerline of the structure.

When paid for as a separate item, slope wall removal will be measured for payment in place and the area computed in square yards (square meters).

Removal of existing culverts will be measured for payment in place, in feet (meters) along the invert of the culvert.

When paid for as a separate item, removal of existing bridge rail will be measured in place in feet (meters). The length measured will be the overall length along the top longitudinal rail element through all posts and gaps. Removal and disposal of all posts and connecting hardware associated with the bridge rail will not be measured for payment.

When paid for as a separate item, the removal of concrete or masonry for partial removal of structures will be measured for payment in place and the volume computed in cubic yards (cubic meters).

Excavation of earth necessary to perform the removal of existing structures will not be measured for payment.

Rock excavation will be measured for payment according to Article 502.12.

501.07 Basis of Payment. When the contract contains a separate item for the removal of a structure, the work will be paid for at the contract unit price per each for REMOVAL OF EXISTING STRUCTURES, REMOVAL OF EXISTING SUPERSTRUCTURES, or REMOVAL OF EXISTING CONCRETE DECK at the location designated on the plans.

When the contract contains a separate item for the partial removal of concrete or masonry structures the work will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE REMOVAL or MASONRY REMOVAL.

Disposal of materials specified for salvage but deemed unfit for further use through no fault of the Contractor will be paid for according to Article 109.04.

The protective shield system will be paid for at the contract unit price per square yard (square meter) for PROTECTIVE SHIELD.

Removal of existing pipe culvert concrete headwalls will be paid for at the contract unit price per each for CONCRETE HEADWALL REMOVAL.

Removal of existing pipe culverts will be paid for at the contract unit price per foot (meter) for PIPE CULVERT REMOVAL.

When a pay item is provided in the contract, removal of existing slope wall will be paid for at the contract unit price per square yard (square meter) for SLOPE WALL REMOVAL.

When a pay item is provided in the contract, removal of existing bridge rail will be paid for at the contract unit price per foot (meter) for BRIDGE RAIL REMOVAL.

When the Engineer directs that earth and debris be removed from culvert inverts, such removal will be paid for according to Article 109.04.

When existing structures or portions of existing structures are encountered which cannot be removed by normal excavation procedures and are not shown on the plans or are not evident in the field and are required to be removed, the cost of such removal will be paid for according to Article 109.04.

Rock excavation will be paid for according to Article 502.13.

A.4. Iowa DOT

Section 2401. Removal of Existing Structures

2401.01 DESCRIPTION.

A. Remove all portions of an existing structure from the project, except the portions that may be required or permitted to be left in place.

B. Unless provided otherwise, all structures or parts of structures to be removed become the Contractor's property.

2401.02 MATERIALS.
None.

2401.03 CONSTRUCTION.

A. Notification for Complete Removal of Bridges.

1. Notify the Iowa DNR by mail and the Engineer, with the "Notification of Demolition" form, no less than 10 business days prior to the start of bridge demolition.

2. If unable to begin work on the original intended start date, notify the Iowa DNR and the Engineer, by sending a revised "Notification of Demolition" form, of the new intended start date. Provide notification of the inability to commence work on the intended start date no later than 1 business day prior to the original intended start date. Failure to notify the Engineer of a change in start date 1 business day prior to the original intended start date will result in the need for a new 10 business day notification to the Iowa DNR and the Engineer.

3. The Contracting Authority has inspected the existing bridge for asbestos. Unless otherwise indicated in the contract documents, no asbestos was found, or it has been removed prior to the letting. The Contractor may use this information to complete the "Notification of Demolition" form.

B. Removal of Superstructures.

1. Dismantle and remove steel structures which may be re-erected in new locations in a manner that will avoid damage to any of the members.
a. Separate members at field connections.
b. Clearly and neatly match mark all members of trusses with white paint before dismantling. Similarly mark all pins, nuts, loose plates, and so on to indicate their proper location in the structure.
c. Clean and coat all pins, pin holes, and machined surfaces with waterproof National Lubricating Grease Institute, No. 3 multipurpose grease, or an approved equal.
d. Wire all loose parts to adjacent members or pack in suitable containers.

2. Concrete superstructures which are to be completely removed may be removed by any means consistent with regulations regarding safety and protection of adjacent property. Complete all operations which might endanger new work before constructing the new structure.

C. Removal of Substructures.

1. Remove substructures of existing structures to 1 foot (0.3 m) below natural stream bottom, unless otherwise provided or ordered. Remove those parts outside the stream to 1 foot (0.3 m) below natural ground surface. Where these portions of existing structures lie wholly or in part within limits for a new structure, remove as necessary to accommodate construction of the proposed structure.

2. Prior to placing new work, complete blasting or other operations which are necessary for removal of an existing structure or obstruction and which may damage new construction.

D. Remodeling of Structures.

1. On remodeling projects, match mark steel superstructure parts that are to be removed and reused. Store as designated in the contract documents. Dismantle and handle in such a way to not impair strength or usefulness of the material.

2. When contract documents require removal of existing concrete, carefully and accurately remove to lines indicated. Do not damage adjacent concrete, exposed reinforcing, or structural steel which the contract documents require to be incorporated into the remodeled structure. Saw match lines 3/4 inch (20 mm) deep where concrete floors are to be partially removed. This depth may require adjustment to ensure that the existing reinforcing steel is not damaged.

3. Demolition by impact methods with wrecking ball, pile hammer, and so on, or by explosives will be permitted only when

superstructures are designated in the contract documents as unfit for re-erection. Apply Article 2403.03, I, when bonding new and old work. Do not use explosives for removing a part of a structure to which an addition is to be made, except in the case of massive sections and only with the Engineer's written permission. When explosives have been used, remove the concrete for at least 6 inches (150 mm) beyond the point of visible damage using methods that will not damage the concrete that is to remain.

E. Removal of Steel.

1. Store structural steel members specified to remain the Contracting Authority's property in neat piles at locations specified in the contract documents or within the right-of-way in the vicinity of the work at points the Engineer designates.

2. Neatly store members of structures which are to be re-erected on skids above the surface of the ground.

3. When the contract documents specify that the removed steel is to become the Contractor's property, the contract documents will show an indication of total lead and total chromium in the existing paint system.

F. Removal of Concrete and Masonry.
Unless otherwise provided, concrete and masonry removed from old structures will become property of the Contractor. Remove according to Article 1104.08.

G. Lumber.

1. If designated for salvage, remove lumber from structures by methods which preserves its usefulness. Remove nails, spikes, bolts, and other hardware from lumber, and pile the lumber in neat piles at locations designated by the Engineer.

2. If not designated for salvage, lumber becomes the Contractor's property. Remove according to Article 1104.08.

H. Other Structures.

1. Remove pipe culverts and other small structures which are designated in the contract documents as suitable for salvage using methods which preserves their usefulness. Store these items nearby within the right-of-way.

2. If not so designated, these materials become the Contractor's property. Remove from the site.

I. Part or All of an Old Structure Lying Outside New Construction Limits.
Unless otherwise specified, for any excavation below finished grade line for the purpose of removing the old structure, place suitable earth backfill material to the original level or to the finished grade line (whichever is the lower) according to Article 2402.03, H.

2401.04 METHOD OF MEASUREMENT.
Lump sum. No method of measurement.

2401.05 BASIS OF PAYMENT.

A. When the contract includes an item for Removal of Existing Structures, payment will be the Lump Sum contract price. When provisions in the contract documents do not cover payment for removal of a structure, including encased culvert pipe, footings, or other unforeseen obstacles to be removed, payment for their removal will include placement of backfill material made necessary by their removal. This payment will be as provided in Article 1109.03, B.

B. The payment for removal of an existing structure is full compensation for:
- Furnishing all material, equipment, and labor and for performance of all work necessary for removal of the old structure from the project, and
- Placement of backfill material made necessary by these operations, and
- If the existing structure will become the property of the Contracting Authority, payment for proper storage, salvage, and delivery of the structure will be according to Section 2555.

A.5. Kansas DOT

SECTION 702

CONTROLLED DEMOLITION

702.1 DESCRIPTION

Controlled demolition is the process of transporting, handling and disassembling the components of an open span structure to result in the complete or partial removal of the entire structure or elements of a structure according to the approved demolition plan. The Contract Documents will identify the category for each structure.

Information on existing structures is made accessible by the Owner, if the information is available. Evaluate project characteristics and prepare demolition plans according to the specified category listed in the General Notes.

Plan and execute all procedures necessary for full or partial removal of the structure in a safe and controlled manner that meets all applicable KDOT specifications and all applicable OSHA requirements.

After concrete removal, or before any steel repairs, test the paint for lead content. Properly handle any lead based paint. See **SECTION 714**.

702.2 DEMOLITION SUPERVISOR

The Demolition Supervisor is the person responsible for all rigging and handling of bridge primary and secondary members. The Demolition Supervisor shall be present at the construction site during the removal of Category B & C Structures.

All Demolition Supervisors must be pre-qualified for the scope, type and complexity of the existing structure. To become pre-qualified, provide proof of experience that the Demolition Supervisor has a minimum of 3 years of experience and at least 5 projects similar in scope, type and complexity.

KDOT will maintain a list of approved Demolition Supervisors on a Pre-Qualified List.

Complete the pre-qualification of the Demolition Supervisor prior to the pre-construction meeting, and/or submit to the KDOT Field Engineer proof of pre-qualification at the pre-construction meeting.

702.3 DEMOLITION PLANS

a. General. The Contract Documents will indicate the demolition category for each structure. Submit shop drawings according to **SECTION 105**.

Develop a unique Demolition Plan for each qualifying existing open span structure in the Contract Documents.

Submit a detailed Demolition Plan to the Owner's Engineer for each open span structure. Address all requirements for removal of the structure to the limits shown in the Contract Documents. Demolition may not proceed until a Demolition Plan has been approved.

During phased/staged demolition, the Contractor's responsibilities extend to the removal limits stated in the Contract Documents for each phase. Do not directly affect the remaining structure outside the removal limits for each phase, or affect the adjacent structure.

Include a Contingency Plan within the Demolition Plan indicating procedures to be carried out if the demolition stage completed does not comply with the Demolition Plan (i.e. the Plan states completion of rail removal, but due to unforeseen obstacles the majority of one rail has been partially disconnected from the existing structure, but it has not been removed).

b. Definitions. The level of review and the requirements for submittals by the Contractor to the Engineer are categorized by risk and complexity.

The Design Engineer will determine and assign the Category of the demolition and will indicate the demolition Category for each open span structure requiring removal on the design plans. Signing and Lighting structures, due to the typical removal procedures, will specify a demolition Category based upon the Signing and Lighting Engineer's engineering judgment. If this information is erroneously omitted, contact the State Bridge Office (SBO). Special considerations will control the selection of the demolition Category.

Controlled demolition of open span structures falls under three separate categories:

(1) Category A. This category requires approval of a Demolition Plan. Demolition typically includes open span structures that will not carry any type of traffic during the demolition operations, structures not adjacent to

traffic, or for structures that do not include a span over any type of traffic. Structures requiring phased removal will be considered for Category A demolition.

(2) Category B. This category requires approval of a Demolition Plan, and a pre-qualified Demolition Supervisor. Demolition will include open span structures with more complex traffic control. Although the removal, or partial removal, may be simple in nature, the structure may continue to carry traffic, be located adjacent to traffic, or include one or more spans over traffic or railroad. Deck or rail replacement, partial depth patching, substructure repair projects or similar controlled demolition activities have the potential to become projects which require a more stringent demolition Category, and as such may be included in this Category.

(3) Category C. This category requires an approved Demolition Plan reviewed by the SBO (or Bureau of Local Projects), a pre-qualified Demolition Supervisor, and the stamp of the Contractor's Professional Engineer. Demolition is defined as the category for open span structures with complex traffic control plans and removal sequences. Complex structures required to carry traffic during demolition operations, are adjacent to traffic, or structures that include one or more spans over traffic (curved structures, severely skewed structures, multi-level interchange structures, etc.) may be included in this Category. A structure with components being removed over traffic or with the potential to fall into traffic is considered to be a Category C structure.

c. Submittals.

Category A Demolition Plans. Provide the Field Engineer with one set of Demolition Plans before demolition begins. Demolition Plans will include at a minimum, as applicable:

(1) A list of all equipment that will be used;

(2) Sequence and limits of removal/partial removal/repair;

(3) Measures to contain falling, or rolling, debris;

(4) Heavy stockpile/equipment loads on the bridge, detailed in accordance with **subsection 702.6**; and

(5) Traffic Control Plan Modification will be according to **SECTION 805**.

No additional requirements apply to this Demolition Category.

Category B Demolition Plans. Provide the Field Engineer with one set of Demolition Plans 2 weeks prior to the demolition meeting. Meet each requirement for a Category A Demolition and at a minimum the following:

(1) A removal sequence showing gravity loads imposed by Contractor equipment and materials.

(2) Proposed methods of demolition, as applicable:

- A list of all equipment that will be used;
- Details of methods to brace the existing structure during demo process;
- Saw cut and/or break point locations;
- Crane pick locations, loads, positions, charts, and rigging;
- Location of protective covers or shields;
- Temporary drainage plan; and
- Proposed backfill after removal of below grade structures.

(3) Specific details for removal will be clearly defined, as applicable:

- Practical environmental conditions limits for removal;
- Detailed Pick descriptions (Length, Center of Gravity, weight, etc.);
- Cross-frame or diaphragm removal sequence; and
- Temporary shoring/falsework details in compliance with **SECTION 708**.

(4) On the Demolition Plans, list the name of the person who is responsible for all rigging and handling of all elements requiring removal. This person, referred to as the Demolition Supervisor, must be present at the site during the demolition of all elements requiring removal. All field operations and field changes are under the authority and responsibility of the Contractor's Demolition Supervisor.

(5) Do not suspend/swing any elements over highway traffic at any time during any stage of the removal procedure.

No additional requirements apply to this Demolition Category.

Category C Demolition Plans. Meet each requirement for a Category B Demolition. In addition, submit the final Demolition Plan details, according to **SECTION 105**, to the SBO (or Bureau of Local Projects) for review at least 4 weeks before the pre-demolition meeting.

(1) The Engineer will require a pre-demolition meeting before any Category C demolition operations begin. The Demolition Supervisor will attend this pre-demolition meeting to discuss any field concerns related to the demolition procedures and to increase familiarity with each existing structure to be removed.

(2) Intermediate Stability. Defined as the point in time when the composite nature, or redundancy of the as-built structure, or elements of the structure, can no longer be relied upon to be stable under dead or live loads. This condition may be due to general or localized degradation of the structure, or due to demolition preparations. Before any connection between the existing structure and the element being removed has been compromised, provide protective stability measures for the existing structure, and for the element being removed. The existing state of the overall structural stability, or stability of particular elements of the structure, may be a major factor in the decision for complete, or partial removal.

- The composite nature and structural integrity of an as-built structure shall be verified before it is relied upon. This requires calculations, procedures and drawings to be developed and sealed by the Contractor's Professional Engineer.
- Field changes causing increased load effects at any controlling portion of the structure must be approved and resealed by the Engineer who originally developed the plans before work begins. This work is under the authority of the Contractor's Professional Engineer.

In no case will the Engineer allow any type of traffic to travel under incomplete structures undergoing demolition without compliance of the Demolition Plan.

d. Calculations. Include the following as a minimum:

(1) Calculations to substantiate structural adequacy and stability for each stage of demolition, accounting for the structure's lack of completeness, various stages of partial connections, or complex structural geometry.

(2) Primary member bearing calculations clearly stating minimum net downward forces at bearing locations at critical stages of removal.

(3) Calculations to determine translations and rotations at intermediate removal conditions.

(4) Design calculations indicating and verifying the load capacity and stability of all temporary supports, falsework bents, shields or covers, and bracing when used to allow traffic to travel under the incomplete structure.

(5) Calculations indicating structural redundancy of the incomplete structure will be required at intermediate stages of demolition. These calculations will be required to account for unforeseen obstacles to the removal process that necessitate halting demolition at an undesignated stopping point.

(6) Using alternative dead and live loading patterns producing the maximum load effect at controlling locations of the as-built structure, the Contractor's Engineer may create an envelope of allowable means and methods for the demolition procedures.

702.4 DEMOLITION INFORMATION RESPONSIBILITY SUMMARY

The Contractor's Engineer shall provide the following information (Category C):

- Plan of the work area showing the as-built permanent support structures of the structure to be disconnected or removed, roads, railroad tracks, waterways (including navigational channel), overhead and underground utilities and other information pertinent to the demolition procedure.
- Removal sequence for all elements of the structure noting any temporary support conditions, such as holding crane positions, temporary supports or bracing, shoring, protective shields or covers, dead man cables, anchor blocks, etc.
- Details describing the number and location of the permanent, or temporary, cross-frames or diaphragms for each stage of removal.
- Details addressing the expected condition of each bearing device for each stage of construction. State the minimum number of positive bearing connections or supplemental connections to each bent cap which will resist potential destabilizing forces.
- Details addressing modified traffic control, utility and railroad issues.
- Demolition Plans to meet general falsework requirements in **DIVISION 700** if falsework bents, temporary shoring, or strong-backs are used to maintain the stability of the remaining structure.

- Contingency Plan specifying the various unintended partial stages of demolition and removal, including end-of-day bracing and stability requirements. The Contractor's Engineer will also need to address real-time concerns arising from the on-going demolition process.

The Contractor's Demolition Supervisor shall provide the following information (Category B or C):

- Verification to the Contractor and the Field Engineer that member reference marks, as described in the Demolition Plan, have been transferred to the existing structure to allow the Contractor and the Field Engineer to conduct a field review;
- Limits for windspeed/gust, or other environmental concerns for crane operations;
- Proposed crane locations for primary picks showing all necessary information;
- Capacity chart for each crane configuration;
- Center of gravity, lift weight (including rigging) for all picks;
- Primary/secondary element removal location and storage;
- Details of any temporary lifting devices to be bolted/welded to permanent members, including stage and method of attachment, capacity, and stage of removal and
- Temporary support details for bridge bearings.

The Owner's Inspector shall require the following (Category A, B and C):

- A dimensionally accurate Demolition Plan, clearly stating the limits of removal, girder line locations, etc., to permanently transfer to the existing structure;
- Requirements for bracing. At the end of each workday, remove, or temporarily brace, the structural elements not properly stabilized to bring these elements into compliance with the Demolition Contingency Plan; and
- All rigging must have capacity stamps, tags or be otherwise permanently marked on the device (per OSHA Standards).

702.5 PRECONSTRUCTION CONFERENCE

Discuss the Demolition Plan at the pre-construction or pre-demolition meeting.

Resolve any questions during the meeting concerning the Demolition Plan or specific demolition procedures to the satisfaction of the Contractor, Contractor's personnel, and the Engineer before demolition begins.

Additional circumstances may be addressed to include within the Contingency Plan. Modify the Contingency Plan to include all situations agreed upon during the meeting.

702.6 CONSTRUCTION REQUIREMENTS

Do not perform any demolition work without an approved Demolition Plan.

Keep the approved Demolition Plans available on site at all times.

Maintain a consistent, core group of staff (supervisors and laborers) through the completion of demolition.

Demolish the existing structure and perform all work required to remove the structure to the limits stated and as detailed in the Contract Documents. Upon completion of the demolition, remove all obstructions or debris resulting from these operations.

Without prior written approval by the KDOT Area Engineer, do not stock pile construction materials, debris, or rubble exceeding the lesser of the posted load limit, or 20 tons. Equipment on the structure must not exceed the lesser of the posted load limit, or the Operating Load Rating for the structure. To request written approval, provide the KDOT Area Engineer plans showing the location, quantity and weight of the proposed materials, debris and/or equipment exceeding the stated limits.

Perform demolition in a reasonable, controlled, methodical fashion. Demolition Plan approval by the Engineer will not and does not relieve the Contractor of the responsibility for the safety of the methods used, safety of the equipment, or from carrying out the work in full accordance with **SECTION 107**.

Demolition is complete when all elements are removed to the limits shown in the Contract Documents and any shoring and debris are removed.

702.7 MEASUREMENT AND PAYMENT

The Engineer will not measure Controlled Demolition, Demolition Plans and Contingency Plans for separate payment. All required work is subsidiary to the other bridge items in the contract.

A.6. Texas DOT

Item 496
Removing Structures

1. DESCRIPTION

Remove and either dispose of or salvage structures.

2. CONSTRUCTION

2.1. **Demolition Plans**. Follow the demolition sequence shown on the plans for bridge structures to be removed, or submit a demolition plan if indicated on the plans. Include in the required demolition plan the type and location of equipment to be used, the method and sequence of removal of the structural elements, and a narrative indicating the stability of the partially demolished structure is maintained throughout the demolition process. Have these plans signed and sealed by a licensed professional engineer when demolished structure intersects active roadways and as otherwise shown on the plans. Submit required demolition plans at least 14 days before starting work unless otherwise directed. Department approval of these plans is not required, but the Department reserves the right to request modifications to the plans when work could affect the safety of the traveling public and when around other transportation facilities to remain in place. Notify the Department 30 days before starting any bridge demolition work to allow for required notifications to other agencies.

2.2. **Removal**.

2.2.1. **Pipes**. Avoid damaging appurtenances determined by the Engineer to be salvageable.

2.2.2. **Concrete, Brick, or Stone Structures**. Portions of structures that will not interfere with the proposed construction may remain in place 2 ft. or more below the permanent ground line. Square off remaining structures and cut reinforcement flush with the surface of the concrete.

2.2.3. **Steel Structures**. Dismantle steel to be retained by the Department or re-erected by cold-cutting fastener heads and punching or drilling the remaining portion of the fastener, air-arc gouging welded connections, and flame-cutting beams along a straight line. The Engineer may approve other methods of cutting. Cut beams at the locations shown on the plans. Match-mark steel to be re-erected with paint in accordance with the erection drawings. Remove steel piles or cut off 2 ft. or more below the permanent ground line.

2.2.4. **Timber Structures**. Remove all fasteners from timber determined by the engineer to be salvageable. Remove timber piles or cut off 2 ft. or more below the permanent ground line.

2.3. **Salvage**. Avoid damage to materials shown on the plans to be salvaged. Deliver materials to be retained by the Department to the location shown on the plans. Block up salvaged steel materials off the ground.

2.4. **Disposal**. Material removed that is not deemed to be salvageable is the property of the Contractor. Dispose of removed material off the right of way in accordance with federal, state, and local regulations.

2.5. **Backfill**. Backfill excavation and voids to the original ground line if resulting from the removal of structures. Place backfill that will support any portion of the roadbed or embankment to the same requirements for placing embankment. Backfill other areas in 10 in. layers, loose measurement, and compact to the density of adjacent undisturbed material.

3. MEASUREMENT

This Item will be measured by each structure or by the foot.

4. PAYMENT

The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Removing Structures" of the type of structure specified. This price is full compensation for demolition plan preparation, loading, hauling, disposal, stockpiling, removal of appurtenances, excavation and backfill, equipment, labor, tools, and incidentals.