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IMPLEMENTATION OF BRIDGE BUNDLING DELIVERY METHOD STRATEGY

Mohamed, M.[1,2], Tran, D.[1,3]
[1]University of Kansas, USA
[2]mamdoh_ali@ku.edu
[3]daniel.tran@ku.edu

Abstract: State departments of transportation (DOTs) and local bridge agencies are increasingly using a bridge bundling approach to obtaining benefits from the economies of scale and enhancing the overall program performance. Bridge bundling incorporates more than one bridge construction/replacement or maintenance/rehabilitation project into one program. This study explores the current practices of implementing bridge bundling methodology with different types of project delivery and procurement methods. To obtain this goal, bridge bundling programs from Pennsylvania DOT, Delaware DOT, and Ohio DOT were reviewed. Further, a case study from Missouri DOT was conducted. The research results showed that, compared to single project delivery, bridge bundling offers several advantages such as (1) improving the performance measures of the highway infrastructure asset system,(2) reducing the number of bridges in a poor condition, (3) providing cost savings and improving project schedule, and (4) early starting construction. Further, bridge bundling reduces the burden on agency staff by preparing procurement for one contract, reducing management oversight, and coordinating with one contractor. This study suggests an eight-step process that bridge agencies can follow to create a bridge bundling contract. These steps begin with identifying bridge inventory and performance goals and end with creating a construction bundle.

1 INTRODUCTION

Several state departments of transportation (DOTs) have used a bundling approach to deliver their bridge replacement/maintenance/construction projects. The word “bundling” refers to consolidation of two or more procurement requirements for goods or services previously provided or performed under separate smaller contracts into a solicitation for a single contract (Government Contracting Terms & Definitions 2018). Over the years, aggregating highway projects into one bundle revealed the potential improving for the construction process. To save cost and time, the Fixing America’s Surface Transportation Act (FAST Act) encourages handling of multiple projects into a single bundle as a one project agreement. Bundling of design and construction stages saves procurement time, leverages design expertise, achieves economies of scale, and builds momentum to maintain the critical assets that are too often in deficient conditions (FHWA 2016). State DOTs or other bridge agencies can use bridge bundling to achieve one or more goals. The most common goals of a bundling approach are as follows:

- Improve project performance and asset management;
- Accelerate work that would not advance as rapidly with traditional methods;
- Save design and construction costs;
- Take the advantage of economies of scale and improve production;
- Take advantage of available funding and financing;

- Coordinate construction staging and reduce public disruption;
- Reduce the number of bridges in poor condition and start construction of multiple bridges simultaneously (FHWA 2016).

Literature review shows that research on bridge bundling delivery approach in construction domain suffers from knowledge gaps, information shortcomings, and implementation is still relatively new to most DOTs. The primary driving force behind this study is the need for a comprehensive guidance plan that assists state DOTs and other bridge owners to use bridge bundling as a viable program option.

The objectives of the study were to (1) provide an overview of the state of literature on bridge bundling and (2) investigate best practices, experiences, tools, and techniques to deliver a bundled bridge program. This study may help state DOTs and other bridge agencies institutionalize bridge bundling contracts and better understand the aspects of creating a bundled bridge project. Bridge agencies can identify the required procedures and considerations, and balance between benefits and challenges.

2 BACKGROUND

The federal legislations have allowed funding bundled programs for many years. Section 1111 of the FAST Act, Bundling of Bridges, adds a provision-23 United States Code (U.S.C.) Section 144(j)- that encourages using Federal funding on bridge bundle contracts (FAST Act 2018). However, the FAST Act requires each bridge project included in a bundle to meet the following criteria:

- Be eligible under either the National Highway Performance Program (NHPP), 23 U.S.C. 119, or the Surface Transportation Block Grant Program (STBG), 23 U.S.C. 133;
- Be included as a bundled project in the applicable Transportation Improvement Program or State-wide Transportation Improvement Program; and
- Have the same funding category/subcategory and the same Federal share.

Further, Section 1106 allows the NHPP funds to pay for improvements of the bridges that are not on the National Highway System (NHS) but on a Federal-aid highway. At the local level, Section 1109 of the same Act makes more federal aid available to local areas through the STBG program. As a result of this legislation, bridge bundling at these areas has shown that it can be cost effective and reduce the backlog of structurally deficient bridges. For instance, rehabilitation and removal of 41structures in three counties were completed into a local bundling pilot by Pennsylvania DOT (PennDOT). The total cost of the program was $25 million, the construction savings ranged from approximately 5% to 15%, meanwhile the design savings raised to be ranged from 25% and 50% (FHWA 2016).

The Bundle 401 project case study of the report presented how Oregon DOT addressed issues related to consultant utilization for the OTIA III State Bridge Delivery Program. Five concrete bridges were replaced with a total bundle cost $46,390,721. First, a new department was created called the Bridge Delivery Unit (BDU) and several consultants were hired to work as a team on the bundle program. Then, the team developed a project delivery process consisting of a series of steps. These steps include bundle development, concept design, draft RFP, design build proposal preparation, scoring and selection, contract award, design and construction, and closeout (Minchin et al. 2014).

Table 1 provides examples of how bridge bundling approach can be integrated with the different project delivery and procurement methods. These three projects cover different aspects such as the number of bridges into one bundle, the range of the costs between the smallest and largest bundles, and examination of different delivery methods and procurement methods.

Table 1: Summaries of bridge bundling projects

Agency	Bridge Project Type	Delivery Method	Procurement Method	Number of Bridges	Cost ($Millions)
Delaware DOT	Bridge bundle program to address large culvert replacements	DBB IDIQ DB	Low Bid Low Bid Best Value	3-5 22 28	1 5.5 11
Pennsylvania DOT	The Rapid Bridge Replacement project.	P3	Best Value	558	899
Ohio DOT	Local bridges replacement. Splitted into smaller contracts.	DB	Low Bid	2-3	1-2

The literature review and examining these three projects revealed that there are five aspects to be considered in bridge bundling delivery methods as shown in the next subsections.

2.1 Stakeholders support

Early in the process, identifying project or program implementation team and development of external outreach plan are important. Public outreach to the stakeholders is crucial for bridge agencies. This may include elected officials, industry, other stakeholders, and the public. The agency gains support and funding resources if all of these relevant parties are engaged and understand the different perspectives and issues (Tran et al. 2016). Development of communication plan with these parties could include identification of the specific organizations needed for support, type, methods, and frequency of communication. This plan enables the project team to see and understand the groups involved and how communication should be conducted.

2.2 Risk management

The process of risk management should be conducted throughout the program lifecycle. Processes such as programming, environmental study, bridge selection process, project delivery and procurement methods selection are all risk allocation decisions that can include threats and opportunities for a program. The literature in the area of bridge bundling risks reveals threats and opportunities associated with program bundling delivery method. Table 2 provides examples of these threats and opportunities and potential responses.

Table 2: Potential bridge bundling risks

Threat(T) or Opportunity(O)	Potential Response
• Unclear goals and objectives (T)	• Get stakeholder input, Documents review.
• Delivery method is not clear (T)	• Utilize project delivery selection tool (risk-based).
• Accelerated delivery (T)	• Use DB or CM/GC delivery method.
• Geotechnical conditions (T)	• Conduct geotechnical investigations during procurement.
• Fixed budget (T)	• Use DB or CM/GC project delivery method, request proposal responder to identify amount of work they can do within this budget.
• Elected officials buy-in (O)	• Educate, develop a communication plan, and secure funding.
• Agency personnel and expertise capacity (T)	• Training, and outsource.

2.3 Bridge bundle selection

When a public agency decides to bundle bridges, it must then decide the optimal size of the project. There is no one-size-fits-all approach to bridge bundling. The size of a bridge bundle can vary widely

depending on factors such as funding available, agency capacity, timeframe, and availability of contractors to construct the program. For instance, the $889 million Rabid Bridge Replacement program by the Pennsylvania DOT includes 558 new or improved bridges (PennDOT 2018). The program is expected to take more than three years is almost completed in less than three years. One of the factors for the expedient delivery of this large number of bridges is the selection methodology of the bridges. However, a bridge bundling workshop held by Federal Highway Administration (FHWA) on successful practices pointed out that to make a bridge bundling work, the maximum size of bundle should be 7-10 bridges and the minimum between 3-4 bridges (FHWA 2016).

The capacity of state DOT or any other bridge agency has a considerable impact on determining the optimal size of bridge bundling program. Factors such as staff resources availability and expertise, the agency's annual budget, and existing funding sources must be considered. Another resource such as local contractors and the capacity of industry in the area is an integral part of determining the correct size of the bridge bundle. In the Safe & Sound Bridge Improvement Program by MoDOT, 491 of the 802 bridges were completed by what is called a *hometown team* with 22 Missouri contractors and more than 100 subcontractors and materials suppliers were involved (MoDOT 2018).

In general, it is important to downsize the contract complications and take advantages of measures to simplify the design, procurement, and increase efficiency in design and construction. Following are several considerations in this regard for an agency):

- Choosing bridges within geographic proximity will help lower mobilization costs;
- Road type, geometry, and traffic effect on bundle selection. E.g., Bridges on local rural roads with less traffic are easier to bundle because they do not require significant traffic analysis and coordination;
- Bridge size between 20 and 100 feet long, with some bridges as long as 150 feet, is ideal for bundling;
- When bridges are bundled by work type, economies of scale and repeatable details are realized and resulting in lower fabrication and construction costs; and
- In addition, identifying candidate bridges by employing bridge selection criteria that meet the program goals while considering risk analysis simplifies bridge screening and selection procedures. (MoDOT 2018; DelDOT 2018; FHWA 2018)

2.4 Program delivery and procurement methods

While the traditional DBB project delivery method remains prevalent among transportation agencies, many state DOTs have been selectively adopting alternative contracting methods (ACMs) to increase collaboration between program parties (Minchin et al. 2014). For bridge bundling contracts, the transportation agencies have typically used either design bid build (DBB) or DB delivery methods.

In the early 2000s, Delaware DOT's (DelDOT) Culvert Replacement Bridge Bundling Programwith $5.5 million adopted indefinite delivery/indefinite quantity (IDIQ) delivery method. The IDIQ methodology helped to expedite the delivery of this bridge bundle and DelDOT did not need to undergo the procurement process for each additional location (DelDOT 2018). Gransberg et al. (2015) defined the IDIQ contracting method as "An indefinite quantity of supplies and/or services whose performance and delivery scheduling is determined by placing work orders with one or multiple contractors during a fixed period of time". A study by Minnesota DOT in 2014 found that IDIQ delivery method creates the capacity to expedite project delivery. An on-call contractor can be mobilized and initiates the work in a much shorter period than the other delivery methods. The study also found a number of advantages when the IDIQ delivery method is implemented in repetitive construction and maintenance projects. These advantages include the ability to obligate unused fiscal year funding, economies of scale reductions in unit pricing, and construction quality improvement (LRRB 2014).

In the same context, many factors affect selection of the most appropriate procurement method. When the nature of the work is straightforward and the bundles are not too large, Low-bid (LB) procurement paired with the DBB project delivery method is usually the optimal option. However, when projects are large and include high risk items, LB procurement may not be the best option. Procurement method such as best value (BV) with DB delivery method are ideally suited for these large and complex projects. Qualifications-based selection (QBS) can also be used for selecting a contractor for bridge

bundles. Factors such as qualifications, experience, and past performance can provide a competitive system when choosing a contractor using QBS procurement method. The CM/GC projects using QBS have significantly less encounters with overruns and claims making this process a viable option for bridge agencies (Molenaar et al. 2014).

To determine the most appropriate project delivery and procurement methods, agencies should conduct risk assessment procedures and adopt mitigation strategies that maximize the program performance and minimize risks. Thus, to assist agencies in selecting project delivery method with considering these strategies, the FHWA and Colorado DOT have developed a project delivery selection matrix (PDSM). This tool provides a risk-based approach using a series of evaluation worksheets and forms. The PDSM considers primary evaluation factors such as complexity and innovation, schedule, level of design, availability of agency staff, and contractor experience (FHWA 2018).

2.5 Quality Assurance Requirements

While recognizing the unique attributes of bridge bundling, agencies must think through how quality will be assured. Subpart B of federal regulations 23 CFR 637 defines quality assurance (QA) as a "systematic actions those are necessary to provide confidence that a product or service will satisfy given requirements for quality" (FHWA 2018). Handling these QA actions is primarily driven by the selected program delivery method. The options are not different from the other types of non-bundling delivery approaches. However, unique factors related to bridge bundling projects should be considered including:

- Bridge construction activates may be taking place in different geographic areas with great distances;
- Large-quantity and frequent roadway permits are required;
- Large quantities of concrete may be needed and the capacity of local concrete plants may be exceeded, and
- The capacity of laboratories should be enough for the number of samples and tests required.

As shown in Table 2, the organization models for QA depending on the project delivery method can be classified based on which party is responsible for QA activities.

Table 2: Bridge bundling quality assurance and delivery methods

Project Delivery Method	Quality Assurance Options
DBB and IDIQ	• By agency in-house staff. • By agency representative (outsourced to consultant).
CM/GC	• Same as D-B-B.
DB and P3	• By agency in-house staff. • By agency representative (outsourced to consultant). • By design-builder (independent consultant).

3 RESEARCH APPROACH

To review and assess the multifaceted benefits and costs of bridge bundling, the research team conducted a comprehensive literature review including academic, industry publications, state DOT websites, and government reports to find the most current trends and practices in bridge bundling. The literature review was conducted by using academic database, general internet search engines, transportation research record (TRR), Federal Highway Administration (FHWA) website, and the ASCE civil engineering database.

Three bridge bundling programs from Pennsylvania DOT, Delaware DOT, and Ohio DOT were investigated. Further, a case study from Missouri DOT was examined in detail. The case study analysis was selected as a research method for this paper because the problem is on a contemporary phenomenon within a real-life context and little control events are available (Yin 2009). The case study

selection was based on many factors such as participation of agency personnel in interviews or telephonic communication and availability of the documents of bridge bundling program. Once the data from the case study project completed, the raw information and the collected relevant documents were analyzed and integrated with data from the literature review (See Figure 1).

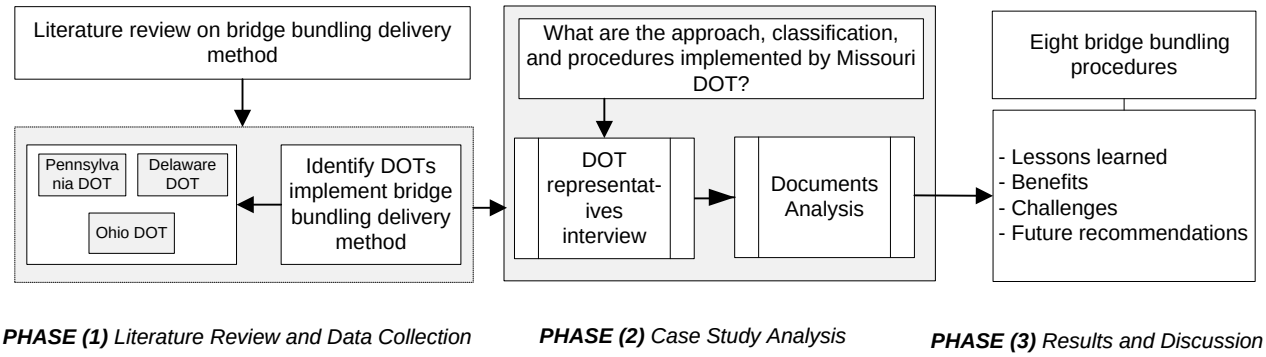

Figure 1: Research approach

4 CASE STUDY

In 2008, the Missouri Department of Transportation (MoDOT) embarked on a revolutionary program for delivering many deficient bridges across the state. This program, named the Missouri Safe and Sound (S&S) Bridge Program, set out to repair or replace as many deficient bridges as possible (Dan et al. 2016). Initially, MoDOT decided to use design–build–finance–maintain (D-B-F-M) for the program, which is a comparable method to P3. However, MoDOT planned to kick off the program in 2008, which was when the economy collapsed as a result of the housing bust. This meant that private development firms had a difficult time obtaining funds from banks to fund the bridge program. As a result, MoDOT decided to use D-B-B and D-B to deliver the projects (MoDOT 2018).

4.1 General Information and Program Inventory

A transportation program in MoDOT is often established based on a specific need or needs of the state. In the case of the S&S program, Missouri had more than 1,000 bridges throughout the state that were classified by the National Bridge Inventory (NBI) rating system as either in “serious” or “poor” condition. These bridges were becoming a safety issue for the traveling public. Therefore, the development of the program was based on the need to improve the safety of travel across the state. Through a state-wide evaluation process, a total of 802 projects were compiled to make up the S&S program. MoDOT acknowledged that it would have been very difficult to coordinate and increase internal staffing to complete the 802 bridge projects individually across the state in the desired five-year period. This challenge led to MoDOT’s decision to package the projects as a program and let them as bundles to constructors.

A critical decision that MoDOT made was to package all replacement bridge projects as one project for the use of the D-B delivery method. A consortium of construction contractors and design consultants (the design–builder) was awarded the bundled D-B project, which included 554 bridges. As an official with MoDOT stated, “Our role for the D-B contract was to handle all of the tasks and activities associated with right-of-way, utilities, environmental requirements, inspections, and community outreach.”

Although the S&S program contained hundreds of projects, MoDOT noted that the actual design and construction work for most of the bridges would be straightforward and would not be complex projects. The average bridge in the S&S program was approximately 147 ft long, 24 ft wide, and 60 years of age. These bridges were located in mostly rural communities, and the average daily traffic (ADT) rate was approximately 1,900 vehicles (approximately 300 of the bridges in the program had an ADT rate of less

than 400 vehicles). This situation provided an opportunity to strategize construction of similar bridge structures, with a focus on speed of construction. The decision to use of D-B-B for the repair and rehabilitation projects was made due to the uncertainty in pricing for repairing a bridge compared to a total replacement of a bridge.

4.2 Bridge Bundling Delivery Performance

Measuring performance of the program occurred on a project-by-project basis along with monitoring specific measures that relate to the overall program goals. Project performance measures focused on the major areas of cost, schedule, quality, and safety. An example of project performance measures is as follows:

- Planned versus actual expenditures;
- Planned versus actual schedule durations;
- Safety by tracking reportable incidents; and
- Quality by tracking repeated Non-Performance Reports.

MoDOT also developed a process to track repeated issues on projects and throughout the program. MoDOT collected and compiled the repeated issues and the solutions, which were then documented in a best practices manual that was revised each time a repeated issue was found. This process helped improve performance continually throughout the program duration.

4.4 Bridge Bundling Benefits and Drawbacks

Overall, MoDOT considered the S&S bridge delivery program a success. MoDOT realized many benefits along with several drawbacks and challenges of this program delivery. This section details the typical benefits and challenges that MoDOT had to overcome to achieve a successful program and accomplish the program's goals.

4.4.1 Benefits

Shortened delivery schedule:

MoDOT realized many benefits that D-B could provide for program delivery. One of the significant benefits of using D-B for the S&S bridge improvement program is to reduce the overall schedule from more than 5 years to 3.5 years. The key to the rapid completion of this program was the strategy to close roads and replace bridges in the same location, eliminating the need for costly roadwork. The average closure was just 42 days.

Improved communications and relationships with contractor community:

Other benefits that MoDOT personnel noted during the interview process include improved communication and development of long-term relationships with constructors. In fact, 22 Missouri contractors, more than 100 subcontractors and materials suppliers, and 21 local bridge builders were involved in this program.

Standardized design elements:

As stated previously, MoDOT realized that most of the bridges in the program would not be technically challenging or difficult to design or construct. Furthermore, many of the bridges were located in rural or sparsely populated areas, so disruptions to motorists would be limited. Based on these situations, MoDOT and the design–builder began standardizing elements of the bridges.

Development of a best practices manual for repeated issues:

Another novel practice that MoDOT implemented on this program was tracking and documenting repeated issues. Once an issue or problem arose on a project, MoDOT along with the assistance of the design–builder had the ability to apply the solution that was successfully used to address similar issues in other projects in the program.

Schedule flexibility:

MoDOT initiated several incentives/disincentives within the D-B contract to help accelerate the program schedule. In addition, MoDOT implemented a “flexibility move” requirement in the contract. This requirement essentially reserved the right for MoDOT as the owner to move the schedule on a limited number of bridges. As compensation, the design–builder was allowed the use of weighted timetables and standard DOT schedule tools to show the different number of typical working days available for each bridge under different conditions.

4.4.2 Challenges

Logistics of coordinating hundreds of bridge projects across the state:

Overall, MoDOT realized early that one of the most significant challenges for the S&S program would be the logistics and coordination of handling so many projects over a set period of time. Thus, MoDOT prepared for what was envisioned based on the substantial amount of time that MoDOT personnel invested into planning for this program. When MoDOT hired the design–builder for the program, they faced the same logistical issues. MoDOT and the design–builder then worked together to develop a plan to address the bridges along major routes to ensure that a limited number of bridges along a route would be under construction at the same time.

Change in the program method of delivery due to economic recession:

In the case of the S&S program, the economic recession created an early challenge as MoDOT initially planned the program to utilize D-B-F-M to deliver and maintain the program of bridges. The economic crisis that began in 2008 drastically affected the ability of private concessionaires to gain financing. As with most transportation construction programs, the total budget can easily exceed $100M. Therefore, financing affects how a program will be delivered or if it can even be delivered at all.

Effective use of local contractors:

Another major challenge that MoDOT had to address was to leverage the use of local contractors. At the beginning, local contractors provided many questions and comments regarding the volume of work of the program to be conducted by a “big” consortium. To overcome this challenge, MoDOT included a recommendation in the D-B RFP that the awarded team would need to gain the support of the local contractors for the individual and the overall program to be successful.

Community outreach:

MoDOT had to handle the majority of public relations for the S&S program. With a program of this size, MoDOT had to rely on their staff throughout the state to help manage the public concerns for the program. Knowing that this would be a huge undertaking, MoDOT included in the D-B contract for the design–builder to support MoDOT in its public relations efforts. Additionally, MoDOT developed a website for the program, which included a state-wide map with an icon for each bridge in the program.

5 RESULTS

With variety in work type, size, and contracting methods, the examination of state and local bridge bundling demonstrates the efficiency of bridge bundling approach. Bundling of bridge preservation/preventative maintenance, rehabilitating, or construction projects, reduces the costs, achieves the economies of scale, and accelerates project schedule. In addition, the maximum benefits occur at project locations with no or minimal right of way (ROW) takings, minimal environmental constraints, sufficient advance geotechnical information, and completed in advance hydraulic analysis. Further, examination of the three DOT programs and MoDOT case study revealed that there is a series of typical procedures to create a bridge bundling contract (see Figure 2).There are numerous of benefits that can be obtained through applying a bundling approach depending on agency’s goals and objectives. These benefits include:

- Maintain or improve performance measures of the highway infrastructure asset system;
- Reduce the number of bridges in a poor condition;
- Save costs due to economies of scale and expedite project delivery;
- Start construction earlier;

- Allow for use of innovative project delivery and procurement methods such as CM/GC, DB, and BV
- Allow agencies to capitalize on funding and finance innovation;
- combine the individual bridge projects of local agencies into a joint bridge bundling; and
- Reduce the burden on agency staff.

However, there are some of challenges that bridge agencies may encounter when they create a bridge bundle. The most significant of these challenges to state DOTs and other bridge agencies are summarized below:

- Local industry may have difficulties keeping up with the large size bridge bundle;
- Limited competition due to large contract size and reduced number of eligible contractors to bid,
- An engineering issue at one location can prevent the entire package from being advertised;
- Some innovative contracting methods, such as CM/GC, may be prohibited by State law; and
- Consuming a large amount of the agency financial resources may have impact on the other projects.

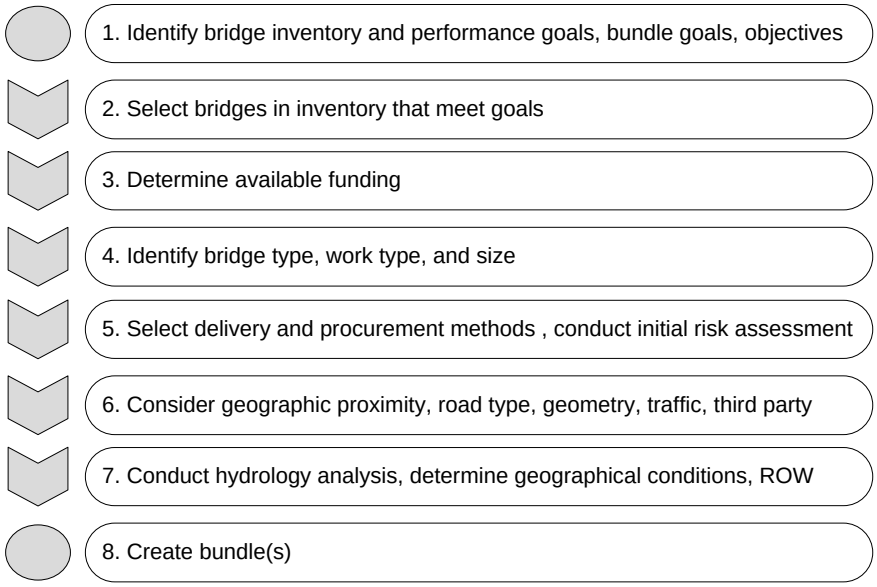

Figure 2: Bridge bundling procedures

6 CONCLUSIONS

Transportation agencies use a bundling approach for replacement and maintenance/rehabilitation of bridges throughout the nation. The findings of literature review and case study projects revealed the successes of bridge bundling approach for DOTs and local agencies. There are several observed benefits of improved performance using bundling such as cost saving due to economies of scale, expedite project delivery, earlier construction start, reduction of burden on agency staff, and improved performance measures. However, the study shows some challenges that state DOTs and other local agencies may encounter include the large size and pace of a fast-moving bridge bundle comparing with the limited local industry, fewer number of bidders, and engineering or construction issue. The case study projects exhibited the potential of bridge bundling approach into the different types of traditional and alternative delivery systems, procurement methods, and bridge construction types. The study concluded with proposing the eight-typical step process to better understand the aspects of creating bridge bundling program beginning by bridge inspection and inventory and up to ROW considerations and contract letting.

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