THE BENEFITS OF ACCELERATED BRIDGE CONSTRUCTION

ABSTRACT

The purpose of this report is to outline the many advantages of accelerated bridge construction (ABC) when compared to traditional methods of bridge replacement. One of the main factors limiting the widespread use of ABC is concern about deck cracking due to inadequate deck joints. However, numerous studies are being done to resolve the issue. As the nation's bridges deteriorate and as building and material technology advance and address strength concerns, there needs to be a stronger push to make accelerated bridge construction the standard method of bridge replacement. Conventional methods of construction ignore user costs, which can sometimes exceed the actual cost of the bridge replacement. Accelerated bridge construction uses prefabricated bridge elements or sometimes entirely prefabricated bridges to reduce user costs by drastically shortening the on-site construction time to hours or days instead of months. In addition to reducing user cost, ABC is also safer for workers, results in a higher quality product, and is becoming cheaper conventional construction methods as contractors become familiar with the process.

INTRODUCTION

As the United States' infrastructure ages, bridge replacements are becoming both more common and more important to ensure public safety. During the development of the modern highway system most bridge and overpass projects involved building structures for new highways. These construction zones were usually in open areas or "greenfields" with no traffic. The lack of traffic allowed for the use of shored framework and large scale earthwork processes that would be difficult to use in modern day bridge replacements, especially in urban areas (Culmo 2011).

Since many of these structures have been neglected or poorly maintained over the past several decades they are now considered structurally deficient or functionally obsolete by the government agencies that own them (Attanyake et al. 2014). It is estimated that about twenty five percent of the country's six hundred thousand bridges require rehabilitation, repair or reconstruction. Due to the relatively poor condition of our nation's bridges compared to the highways themselves, individual bridge replacements that are not part of an overall highway reconstruction project are now more common. Since the streets and highways are still functional, traffic control has become a significant piece of the overall process of bridge replacement (Culmo 2011). A major factor preventing the widespread use of ABC is the concern about cracking along deck joints. However, experts in the field are researching solutions and finding creative answers. As building and material technology advance and as the nation's bridges continue to deteriorate, there needs to be a stronger push to make accelerated bridge construction the standard method of bridge replacement.

CONVENTIONAL METHODS AND USER COST

The negative effects of traditional bridge replacement on the economy and our everyday lives need to be taken into account when determining the cost of a project. Bridges play a vital role in commercial and industrial activities, so total closure to traffic during reconstruction can greatly impede the nation's prosperity (Duan and Wai-Fah 2014). Conventional methods used to control traffic and replace a bridge without completely impeding passage include diverting traffic with a detour, constructing a temporary bridge and bypass road, and employing stage construction techniques (Culmo 2011). However, all of these methods negatively affect traffic. Since even a simple bridge can take months to build using conventional on-site techniques due to the time it

takes to sequentially construct the foundation, substructure, superstructure and roadway, reconstruction can disrupt the economy for several months or even years. During peak travel season as much as twenty percent of the highway system is under reconstruction (Duan and Wai-Fah 2014). This has a significant impact on users. However, road user costs are often neglected when comparing reconstruction alternatives. Costs to the public can include longer travel times, additional mileage traveled due to detours, business lost due to consumers avoiding construction zones, and inefficient movement of goods and services (Hallmark et al. 2012). These costs can often exceed the price of the structure itself (Culmo 2011). When taking the effect on traffic into account it becomes apparent that a better method for bridge replacement is necessary.

ABC OVERVIEW

Accelerated bridge construction is the relatively new practice of replacing bridges and overpasses in just hours or days instead of the several months needed to construct a new bridge using more conventional methods. The bridge, or its components, are built off site and finished even before traffic control cones are set up at the job site. Then the bridge is quickly set in place, completed, and opened back up to traffic in just hours or a few of days at most (Hallmark et al. 2012). This process is possible through the use of prefabricated bridge elements (PBE). Prefabrication levels can vary from small components such as girders to an entire bridge. Often prefabricated steel or prestressed concrete girders in addition to composite concrete decks make up the main elements of the bridge. However, in some instances entire structures have been fabricated off-site under strict environmental controls and shipped to the construction site to be erected in as little as one day. This method requires the use of huge vehicles called self propelled modular transports (SPMT) that can move entire bridges and position them into an exact position

(Hallmark et al. 2012). Although accelerated bridge construction is gaining momentum, concerns about this new method have restricted its popularity.

CONCERNS AND SOLUTIONS

Use of ABC has been limited so far due to concerns about the effect of unexpected delays, cracks in the deck, and the strength of the joints between deck sections, but as the industry becomes more familiar with accelerated bridge construction and more research is performed, these concerns will be put at ease. In the tight schedules characteristic of ABC there is little to no room for error. If a component of the bridge was fabricated to the wrong dimensions or some unexpected conditions are found on site, the entire project could be delayed several months and end up being hundreds of thousands of dollars over budget. This is a major concern for government agencies trying to minimize the impact on the public and control costs. However, as more companies become familiar with ABC and standard practices are developed, there should be fewer mistakes and unforeseen circumstances. The joints between precast deck section pose another concern as they are the weak point of some bridges constructed using ABC. If the joints crack or allow the deck to bend and crack then water and deicing salts can get in and cause corrosion and spalling that can severely damage the structural integrity of the bridge. There has been a lot of research in this area of ABC and different methods for joining deck sections are being developed.

Several alternatives to attempt to solve joint weakness that cause cracking are being researched and attempted. The first method used to connect different prefabricated deck elements was welding together two steel plates attached to the deck panels. However, these connections could

not do much to resist bending and the bridges developed cracks along longitudinal joints (Zhu et al. 2012). Another method that is being investigated is the use of lapped U-bars as reinforcing in quick curing concrete. These connections are able to better control flexural cracks, but more testing is required to determine how they perform in fatigue. A different method involves the use of ultra high performance concrete (UHPC) in the closure pour that connects the deck segments. Ultra high performance concrete has a compressive strength of over 30 kis, post-cracking tensile strength of 1.5 ksi and is nearly impenetrable to chloride ions (Hallmark et al. 2012). This method is advantageous because it allows for the use of shorter shear studs and saves time and money by not requiring posttensioning. The newest idea is a dry joint alternative that involves male and female concrete keys that transfer the lateral and vertical forces and prevent vertical displacements between the deck elements (Hallmark et al. 2012). There is still a lot of research to be done to determine the most reliable methods, but the rate of progress is encouraging. Meanwhile, the Federal Highway Administration recommends reducing the number of joints, using one prefabricated deck element, or completely assembling the bridge off site and moving it into place as one unit using SPMTs whenever feasible. This build-and-slide method is gaining ground in the US, but still has not yet become as popular as other ABC methods.

ADVANTAGES OF ABC

Despite these concerns, ABC has many advantages, including being cheaper than traditional bridge replacement. Not only is accelerated bridge construction cheaper in terms of user cost, as previously mentioned, it is often comparable in material and labor costs as well. For example, a bridge that needed replacing in southwest Michigan was estimated to cost $2.85 million dollars using accelerated bridge construction compared to an estimated $2.3 million dollars for

conventional construction. While ABC initially seems more expensive, the overall savings from the user cost due to the reduced duration of traffic obstruction was estimated at $972,000. When this user cost estimate is added to the conventional construction estimate ABC becomes the far cheaper alternative at $2.85 million rather than $3.27 million (Attanyake et al. 2014). This was fairly early in the development of accelerated bridge construction methods, so the original estimated cost of the bridge was higher than standard methods (excluding user cost). However, more modern techniques have greatly improved the efficiency of ABC projects. In general, the more prefabricated bridge elements are used on a project, the less they cost (Hallmark et al. 2012). This is why over the past few years construction costs for ABC projects have started to become more and more competitive (Duan and Wai-Fah 2014). Now, agencies that use ABC and prefabrication find that bid prices are often lower than traditional construction, especially from contractors that have done ABC projects before. Once prefabricated bridge elements, connections, construction procedures and the various other construction details become standardized and more familiar throughout the country, accelerated bridge construction should consistently have lower initial construction costs than the alternatives (Hallmark et al. 2012).

In addition to being cheaper than typical construction methods, ABC is also safer and produces a more reliable product. As mentioned, accelerated bridge construction greatly reduces the duration of the construction job. Shortening the length of the job reduces the amount of time workers are out in the field being exposed to the many safety hazards associated with construction sites. Injuries, therefore, occur less frequently on ABC jobs than conventional bridge construction projects (Culmo 2011). The reduced contact with traffic also increases the safety for the construction workers. Incidents involving workers either directing traffic or

working near open lanes are fairly common on construction sites. ABC removes this hazard by closing the site off from traffic completely during the hours or days it takes to replace the bridge rather than diverting traffic around the site for several months (Culmo 2011). Not only is the method safer for the workers, but the end product is also safer and more reliable. Prefabricated bridge elements are higher quality and more durable than cast in place concrete elements due to the fact that they can be poured and cured in a much more controlled environment. Atmospheric conditions such as high or low temperatures, wind, and rain can adversely affect the ultimate strength of cast in place concrete, but when making prefabricated elements off-site these variables can be controlled (Zhu et al. 2012). The use of higher-quality prefabricated elements in accelerated bridge construction means that the bridges themselves have the potential to be stronger and more reliable than the same bridge if it were built in place.

CONCLUSIONS

Many of our nation's bridges are structurally deficient and need to be replaced. Conventional bridge replacements are complicated by heavy traffic that can add a significant amount of user cost to a project. In order to reduce this cost and produce a safer, more reliable product, the use of ABC should be encouraged. Accelerated bridge construction uses prefabricated bridge elements to quickly install a bridge in just a fraction of the time. It has many benefits including increasing construction worker safety, reducing the user cost, providing a more reliable product, and saving money on the overall project. The main factor delaying ABC from becoming the standard involves deck cracking due to weak joints between deck panels. However, there is a great amount of research being done to find a solution. Accelerated bridge construction is the way of the future.

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