2007 FHWA Seismic Accelerated Bridge Construction Workshop Outcomes and Follow-up Activities

Rapid Bridge Construction: Seismic Connections Moderate-to-High Seismic Zones

Thursday, October 11, 2007

Final Report

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Summary Report

This report details the discussions stemming from the accelerated bridge construction workshop conducted in San Diego, California on October 11, 2007. The focus of the workshop was accelerating bridge construction in moderate-to-high seismic regions, with a particular emphasis on seismic connections. Sponsorship was provided in part by the Federal Highway Administration (FHWA), the California Department of Transportation (Caltrans), the Transportation Research Board (TRB), the National Steel Bridge Alliance (NSBA), and the National Concrete Bridge Council (NCBC).

Background

FHWA has been actively promoting the advantages of accelerated bridge construction (ABC). Proven benefits include minimized traffic disruption, improved work zone safety, and reduced on-site environmental impacts. Related traffic impacts derive from both expedited congestion relief projects and minimized traffic disruption due to reduced on-site highway construction activities. Safety enhancements benefiting the motoring public and highway workers, as well as lessened environmental impacts are directly attributable to limiting in-situ work requirements. For these reasons, European and Asian countries have already embraced the ABC philosophy for many of their urban construction projects.

Working in concert, bridge owners, FHWA, researchers, and industry have developed techniques successfully applied in many states over the past few years. Momentum has been building nationally, fueled in part by successful applications touted in numerous presentations at various conferences, as well as focused meetings and workshops targeting opportunities to advance the state-of-the-art. FHWA and NCBC sponsored an accelerated bridge construction workshop in Reno, Nevada in May 2006. A broad range of issues were presented and debated during that workshop. Additionally, FHWA, the Precast/Prestressed Concrete Institute (PCI), the Precast/Prestressed Concrete Institute Northeast (PCINE), and the National Cooperative Highway Research Program (NCHRP) have been developing guidelines for designers contemplating ABC on projects. While some research has been initiated on connection details for moderate-to-high seismic regions, in general these connections remain a major unresolved issue.

This workshop, focusing on seismic connection details, was conceived during discussions at the inaugural Seismic Accelerated Bridge Construction meeting conducted during the January 2007 86th Annual TRB Meeting. During the meeting, several presentations concluded or implied the need to further address seismic connection detailing before ABC techniques could gain widespread acceptance and application in regions of moderate-to-high seismic activity. Since a considerable portion of the land mass encompassing the United States of America must address seismic loads in bridge designs, the workshop was intentionally not limited to a single state or region, but rather connection detailing in moderate-to-high seismic regions throughout the country.

Purpose

The purpose of the workshop was to assimilate ideas from a broad spectrum of experts focused on connection details to advance ABC applications in moderate-to-high seismic regions. These ideas were roughly categorized as readily implemented, requiring some degree of research, legislative action, or a measure of institutional change (reference Appendix H). A follow-up to this meeting developed a strategic action plan for advancing application of ABC in regions of moderate-to-high seismic activity, which is included in this report. Additional follow-up meetings will focus on future research and resolving implementation issues.

Process

A steering committee was established to coordinate the workshop and follow-up activities. The steering committee included participation from FHWA, Caltrans, TRB, and consulting experts. Current members are tabulated below:

NAME	AFFILIATION
Ray Wolfe	Caltrans
Michael Keever	Caltrans
Kevin Thompson	California State Bridge Engineer AASHTO T-3 Vice-Chair
Rich Pratt	Alaska State Bridge Engineer AASHTO T-3 Chair
Ben Tang	FHWA
Vasant Mistry	FHWA
Stephen Maher	TRB
Mary Lou Ralls	TRB Structures Section Chair
Harry Capers	TRB AFF10 Chair
Ian Buckle	TRB AFF50 Chair

TABLE 1. Workshop Steering Committee

A group of invited academicians, design, construction, and maintenance professionals were assembled representing seismic-prone regions of the United States (reference Appendix A). Prior to arriving at the meeting, each was asked to prepare for the discussion by researching the topic, thereby extending previous related activities in the area of ABC. Specifically, participants were requested to review FHWA's website http://www.fhwa.dot.gov/construction/accelerated/wsaa0601.cfm; the information posted at http//www.fhwa.dot.gov/bridge/prefab/pbesreport.cfm from the ABC workshop conducted in Reno, Nevada in May 2006; and the "Guidelines for Accelerated Bridge Construction using Precast/Prestressed Concrete Components" developed by the PCI Northeast Bridge Technical Committee and available for download at http://www.pcine.org.

Program

The workshop commenced with a number of presentations to set the stage for the brainstorming and subsequent breakout session discussions. Welcoming remarks and motivational statements were provided first by Kevin Thompson, followed by remarks from a panel of experts as delineated below. The actual program is included in Appendix B, with brief summaries of each presentation provided in Appendix C.

TITLE	PRESENTOR	AFFILIATION
FHWA Perspective	Vasant Mistry	Senior Bridge Engineer, FHWA
TRB Perspective	Stephen Maher	Engineer of Design, TRB
Update on nationwide state of practice and advantages	Mary Lou Ralls	TRB Structures Section Chair
An inventory of completed/ongoing research	Ray Wolfe	Chief, Office of Bridge Design South 2, Caltrans
Successful deployment of ABC	Bill Duguay	Area Manager, J.D. Abrams, L.P.

TABLE 2. Presentations

Following the morning presentations, a brainstorming session was conducted to leverage experiences and expertise of all workshop participants. Any ideas related to ABC were encouraged, including those that may not fit precisely within the confines of the workshop focus on seismic connection detailing (reference Appendix D). Ideas generated were categorized as listed below.

Those that were not specifically related to the workshop goals were captured and recorded for future consideration. The group was then tasked with prioritizing the ideas for further assessment in the breakout sessions. Individuals were provided free rein in assigning priority. Each was given five votes to be cast for five different ideas. The tally from this voting system resulted in rankings from *A* to *D*, with "*A*" being the highest classification and "*D*" the lowest. Ideas classified as "A" received six or more votes, those denoted as "B" receiving five votes, three or four votes for category "C", and two vote accumulators classified as "D" (reference Appendix E).

CATEGORY	IDENTIFIER
Industry issues	A
Seismic	B
Substructure	C
Funding costs	D
Process	E
Foundations	F
Materials	G
PS&E	H

TABLE 3. Brainstorming Idea Categories

The highest priority ideas were parsed between four breakout groups, with each receiving five concepts to further develop, at least one in each priority categorization. Many of the ideas receiving votes were similar in nature. An initial review of the raw ideas led to some pairings before the group tally commenced. Care was taken during this endeavor to the extent possible to avoid jeopardizing brainstorming ideas by arbitrarily lumping with another deemed similar. Several breakout group discussions further combined ideas, reducing the number of outcomes somewhat. Each breakout group included experts from academia, industry, FHWA, and State DOTs (reference Appendix F for a listing of each breakout group). This assemblage of expertise precluded the need to assign specific category ideas to a particular group, ensuring a robust discussion. The breakout session groups were provided a formatted list of questions (reference Appendix G) designed to stimulate and guide their discussion. The intended outcome was an understanding of the associated obstacles and opportunities required to advance the idea. The groups were encouraged to develop their ideas as far as time and energy allowed, even to the point of developing a draft action plan (reference Appendix H for populated issue templates).

Outcomes

The following summarizes the discussion documented for each idea from the four breakout sessions. An abbreviated title with the idea number in parenthesis enables tracking back to the more detailed information contained in the appendices. The associated detailed forms used to spur discussion on each topic are included in the appendices (reference Appendix H). It is expected that the summary included herein serves as a starting point to guide future action planning discussions, as well as developing research needs.

Table 4 provides a quick overview of those ideas associated with the top two categories through voting of the workshop attendees at large. It is anticipated that these ideas will be advanced through syntheses or additional focused research as necessary. Clearly, connections issues rise to the forefront of the discussion in many of these ideas. The last column of the table provides tentative recommendations of needs for each tabulated idea; such as synthesis studies, or focused research. A variety of funding

CAT/ NO.	RAW SCORE	CAT.	RANK	IDEA DESCRIPTION	RESEARCH NEEDS SUMMARY
F1/F2	15	A	1	Footing/pile and cap/pile connection	Synthesis, rank, and develop promising ideas
C1b	8	A	2	Connections/tolerances	Synthesis, rank and study
B2	6	A	3(1)	Accelerated post-earthquake repair	Synthesis and developmental effort
H6	6	A	3(1)	SABC code recommendations	Research
B6	5	B	5(1)	Segmental columns with isolation bearings	Synthesis, investigate applicability of non-seismic ideas to seismic applications, testing
C3	5	B	5(1)	Hybrid connections from other industries	Synthesis, rank, research, trial implementations
C6	5	B	5(1)	Integral cap/precast column connection	Synthesis, rank, research
D2	5	B	5(1)	Demonstration projects	Synthesis, rank and study
F3	5	B	5(1)	Grouted voided connections	Not addressed in breakout group

(1) Received the same score, so no preference assigned herein.

TABLE 4. Seismic ABC research needs

vehicles will be pursued to advance these as needed, including NCHRP, FHWA and pooled DOT fund sources.

Post-earthquake accelerated column repair/replacement (B2)
Discussions of ABC have largely centered on rapidly constructing new or replacement structures; however, another benefit derived from developing ABC technologies is rapid repair of damaged structures. Rapid repair of columns is the focus of this idea, and certainly represents the quality “out-of-the-box” thinking envisioned when planning the workshop. The group discussion pointed to both temporary and permanent applications of column repair/replacement. Existing technologies such as steel casings and carbon fiber wrapping were considered as viable options, but more research was also suggested to develop new methods and associated specifications. The ability to match existing aesthetics was considered important, and input from the construction industry considered essential.

Investigation of column seismic connections for ABC (C6, C8, and C10)
The proposal herein was to develop new connection details adequate for seismic loading. Adequate connection between precast columns and superstructures is important so as to provide more viable options for designers. The outcome of such research would be thorough testing, documentation of connection performance capacities, design examples and details, as well as design specifications. Test protocols should consider various levels of performance demanded, as they vary from one region to another in terms of seismic demand. Initially, a review of existing research was necessary to develop promising new technologies or advance existing ones through testing and calibration. Subsequent research focusing on one or more similar connection concepts could then be managed, with new marketable products defining the expected outcome. Care must be taken in such research to preclude proprietary issues that often plague similar efforts and reduce novel ideas to unusable products in the public forum.

Response of segmental systems (C4a, b, c, and B5)
The use of segmented superstructures has seen rapid growth in the past decade (reference Figure 1). However, more research is necessary to understand the seismic response of segmented structures. In general, a better understanding of jointed structure response is necessary – currently designed as emulative system. Advantages of allowing joint opening in large design events can be leveraged towards energy dissipation. This leads to a redefinition of desired performance level goals. This idea is not unlike rocking columns in that areas of high stress concentrations must be carefully investigated and detailed according to desired damage threshold values. The group felt that a focused workshop addressing the fundamental behavioral issues of jointed systems and providing comparison to monolithic designs was warranted. Analytical and experimental testing to quantify hypotheses was proposed. Similar work is underway currently at UCSD.

Additionally, a synthesis to gather and assess the response of existing jointed and segmented bridges subjected to large earthquakes was viewed as a means of identifying further research direction in developing a solid understanding of related behavioral response. Cited areas of concern included corrosion protection, and post-event inspection procedures and tools.

Connections – Ductile, Constructible, Rapid (C1b, D2, and E13)
Tolerances led this discussion. Constructible connection details for precast elements such as bent caps, footings, and pile heads require flexibility to allow for field corrections. They also should be verifiable during construction and later while in service. Developed details for SABC must consider simplicity or the connection detail may not find a niche in the growing market for ABC applications. The group cited a number of examples from current standards to those under investigation. Since connections are important elements in the success of ABC in regions of moderate-to-high seismicity, it was felt that a list of viable ductile connections was needed, followed by an assessment of further research needs and prioritization based on simplicity. Industry participation in this effort was deemed essential to ensure successful transition to field application. Final guidance developed must be comprehensive and include design examples where applicable.

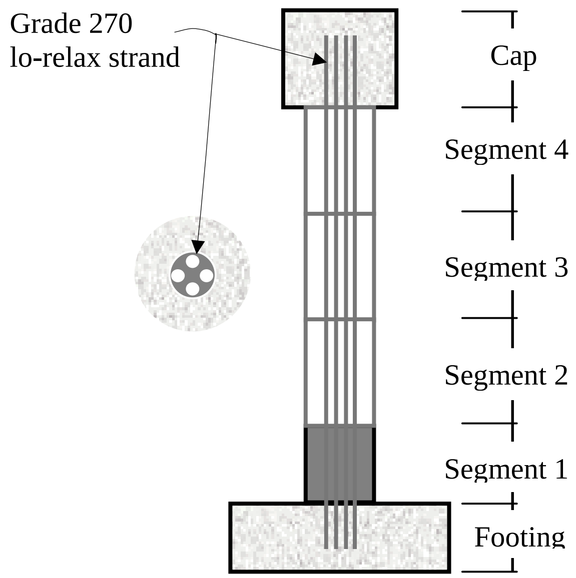

FIGURE 1. Segmental column idealization

Demonstration projects were suggested in high seismic regions to test the constructability of specific proposed connection details, with short- and long-term monitoring established to quantify service-life performance. Close collaboration with contractors and industry representatives was considered essential to meeting the goals of simple, constructible and reliable ductile connection details for SABC applications. Depending on the application and timing relative to implementation, legislation may be required. As an example, if industry participation is demanded in the planning and design phases of a project to develop and employ new connection details specific to the project needs, some states may require legislative approvals. This is akin to the "design sequencing" philosophy used in several states in the past decade, or perhaps product "sole source" desires.

Rocking columns (B6)

This energy dissipating mechanism holds promise to reduce demands on the precast column and its connections. It has been used in New Zealand and Japan on bridges and buildings. Furthermore, New Zealand is researching rocking energy dissipation for retaining walls. Done correctly, the precast column or segmental columns experience a degree of self-centering after a seismic event. A concern that requires more study relates to the stress concentrations at the corners of rocking elements. Consideration should be provided in design of rocking elements to address these high stress zones, and inspection procedures are necessary to confirm performance and damage states after an event. These are critical areas requiring research attention. A synthesis study to review existing knowledge, including the building industry and abroad, was considered a first step, with possible research stemming therein. Potential research should carefully model high stress concentrations and develop sound engineering solutions to protect vulnerable members.

Segmental post-tensioned columns (connections) (F6)
Segmented post-tensioned columns are currently the subjects of intense research nationally and internationally. This subject is quite similar to that on “Rocking Columns” above, yet the two were not combined in the breakout discussions. Variations of this idea include bonded versus unbonded tendons, and mild steel crossing joints. Bonded tendons tend to provide emulative response; that is, behavior similar to conventional cast-in-place concrete columns. A major advantage of unbonded post-tensioning is the inherent self-centering feature for large displacements (reference Figure 2). Additionally, unbonded systems may provide for energy dissipation through joint opening and closing where mild reinforcement is not employed. The University of California at San Diego, the University of Washington, the State University of New York in collaboration with researchers in Taiwan, the University of Nevada-Reno, the University of California at Berkeley, and others in Japan and elsewhere are all investigating variations of this concept. Test results completed to date indicate segmental column performance using bonded and unbonded prestressing tendons may be equal to or better in general than conventional cast-in-place columns. Issues requiring careful investigation include tendon corrosion for unbonded systems especially where joint opening is allowed, creep monitoring, and post-event inspection. Additional research targeting these areas was considered warranted.

Footing-to-Pile and Column-to-Foundation connections (F1 and F2)
This idea received the most votes. It was recognized that successful applications of many different footing-to-pile and column-to-foundation connections have been realized outside of seismic regions. Although some research is underway as evidenced in the morning session discussion, more studies are necessary. The group sought simple, robust, repeatable designs that are economical, constructible, and maintainable. These were the basic concepts Bill Duguay promoted as essential to the success of SABC connections from a contractor perspective in his morning presentation. The first step suggested by the group was a synthesis study to review related efforts by various states and agencies.

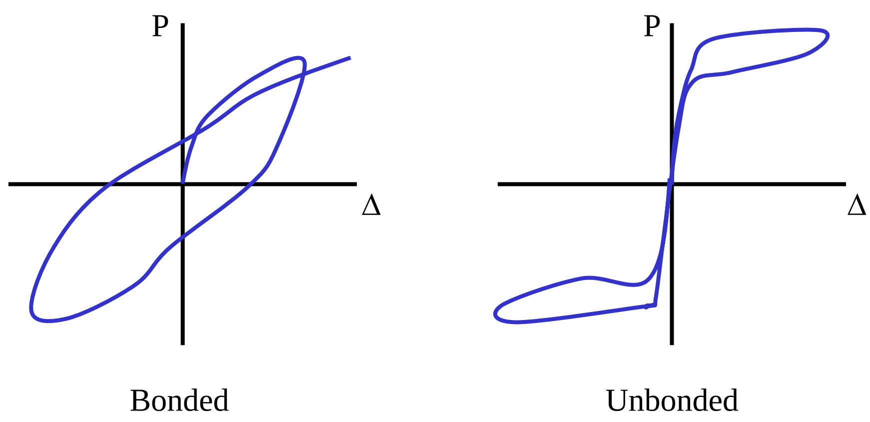

FIGURE 2. Bonded/unbonded tendon performance

Research efforts currently funded through NCHRP, State DOTs, or others are an integral component of this study. The outcomes of the synthesis were expected to guide future targeted research. Such research could be a redirection of on-going efforts, or entirely new, guided work.

Innovative materials (G1)
A synthesis study was recommended to identify innovative material applications, tabulate material properties, and define availability. Material availability was recognized as an important element in application viability, with concerns over the high manufacturing cost of some materials such as composites. It was further recommended that the synthesis be followed by targeted research as appropriate to develop promising technologies to the point that they are readily implemented. Finally, trial applications were considered important to showcase proposed technologies. As the title of this idea suggests, research herein is continuous. Recognizing this, and understanding that innovative material applications take time to develop, the group proposed emulative response for initial applications, followed by more innovative methods as the technology matured.

Segmental construction connection concepts (C3)
It was generally accepted that segmental construction techniques employed not only in bridge superstructure construction, but also in the building industry, could potentially be leveraged for advancing bridge construction. A synthesis study was suggested to identify promising techniques. The outcomes of this study should propose viable concepts and develop criteria for application. Additional research needs could stem from the synthesis study. This topic should be merged with ideas C4a, b, c, B5, and perhaps F6 for research advantage.

Long-term performance of SABC connections (G2)
The concerns listed herein related to the long-term performance of connections details for SABC. Certainly, accelerated environmental tests were deemed essential when qualifying new ideas or innovative applications of existing technologies. Additionally, the lack of reliable nondestructive test tools for many evolving technologies holding promise for ABC in moderate-to-high seismic regions was discussed. Maintainability and confirmation of in-situ performance were considered important to successful deployment of many technologies. Predictable performance of structures, an area receiving more attention recently as calibration adjustments are underway with the AASHTO LRFD Design Specifications, and as extended system and component durability is demanded, requires a solid understanding of long-term performance. Structural health monitoring concepts were considered an important element in quantifying long-term performance of innovative connection details for SABC applications, especially since oftentimes, designs employing special connection detailing to address seismic demands rely on a prescribed performance level during infrequent seismic design events.

Code recommendations for SABC (H6)
Rather than an opportunity for research, this concept is something that should be part of the implementation strategy for every idea considered. The group recognized this as the end result of well-managed research. Codification ensures standardization, and provides a measure of liability protection to the engineer of record. Standardization leads to repeatable, biddable and constructible details, which hopefully are robust in nature so as to minimize or create manageable maintenance concerns. The action plan for this topic provides a draft conclusion for every research project undertaken. The importance of this idea lies in the underlying message its author conveyed; that is, innovation will only succeed and realize widespread deployment when it is thoroughly developed and standardization is a reality.

Follow-up Meetings

Two meetings have been scheduled during the January 2008 TRB Annual Meeting, as shown below, to further develop next steps. The first meeting will provide an overview of the October 11 workshop outcomes, a review of the subsequent action plan, a discussion of current research, and further open discussions related to direction. The intent of discussions herein is to capture new ideas that might emerge from a slightly different audience, recognizing the dynamics involved in processes largely materializing from research as in this subject matter. The second meeting will be a working meeting to develop specific research problem statements. These will largely derive from the two top prioritization categories (A and B) developed at the workshop and shown in Table 4.

- Seismic ABC Collaboration Meeting, Part 1: Tuesday, January 15, 3:45-5:30 p.m., Marriott
- Seismic ABC Collaboration Meeting, Part 2: Tuesday, January 15, 7:30-9:30 p.m., Marriott

Conclusions

The general consensus was that opportunities exist covering a wide spectrum of technologies to employ ABC in regions susceptible to moderate-to-high seismic zones. Some ideas were considered ready for deployment, while others simply required synthesis to document the state-of-the-art. Finally, a number of research opportunities were suggested to advance promising ideas to the point of deployment. Showcase applications funded in part by FHWA were considered an important component in gaining widespread acceptance and ultimately widespread application of various technologies.

The follow-up meetings at TRB will be crucial to the continued advancement of the ideas brainstormed at this workshop. It is expected that those ideas receiving the highest priority during this workshop, and which were identified as requiring research to advance the concept, will be discussed further and research proposals developed at the TRB meetings. For example, the connection between columns and foundations (idea

F1/F2) was the highest priority from this workshop (reference Appendix E). Research needs were identified beginning with a synthesis, followed by additional studies identified upon completion of the synthesis. The identified goal of this research is a simple, robust, economical, and inspectable detail for the column to foundation connection.

A final thought not entertained in the workshop, but discussed among members of the Steering Committee afterwards is the need for a synthesis study to gather information on the state-of-the-practice in superstructure to abutment connections for seismic regions. California has developed several details, which are not widely known or employed beyond the state limits.

It is important to share the developing knowledge in this arena with peers in academia, industry and DOTs. A recognized key to implementing ABC is to work with industry groups to garner agreement on the most promising connection details, and to develop standardized prefabricated components and cross-sections that industry will support. Research needs should derive from industry focus groups to ensure successful deployment. Bill Duguay succinctly stated in his morning presentation that successful deployment requires efficient design. Simplicity of design and specifications factor heavily into motivation; risk assignment must be equitably shared such that the contracting industry will bid on projects stipulating specific connections. Simplicity of design leads to lower costs and higher quality. Repeatability, durability, reliability, adaptability, survivability and profitability are all key elements that must be factored in the development of new connection details. Careful consideration of these will lead to the development of concepts that will prove successful in application. All available vehicles to accomplish this goal should be explored, including a TRB "E-circular" and presentations at various events. As this will remain an on-going effort for some time, periodic updates will be necessary.

Seismic ABC Action Plan

The Steering Committee convened immediately following the workshop largely to develop an action plan to guide future activities stemming from discussions at the workshop. Five categories evolved: (1) *Industry Engagement*, (2) *Project Development*, (3) *Contract Elements*, (4) *Share Lessons Learned*, and (5) *Maintenance Issues*. These were further subdivided into supporting actions leading to successful development within each category. The action plan follows.

1. *Industry Engagement*
    a. Conduct workshop with fabricators, erectors, trucking, and general contractors to assess the most effective steps that can accelerate bridge construction in moderate to high seismic zones.
    b. Assess the most feasible connections from a Contractor's standpoint including constructability, allowable tolerance, cost, time savings, etc.
    c. Determine weight, length, geometric and other parameters associated with picking and transporting ABC prefabricated components (precast concrete, steel, etc.).

d. Identify current capabilities of fabricator facilities and discuss future capabilities with regard to shapes, geometry, etc. associated with prefabrication beds. Consider curvature, round vs. rectangular shapes, non-standard vs. standard shapes, tree structures (e.g. precast monolithic joint in plastic hinge zone vs. joints connecting at member interfaces), use of connectors and inserts in precast members, etc.
e. Discuss most effective contractual methods to accelerate construction.
f. Discuss use of new materials, including high performance concrete and steel.

2. *Project Development*
   a. Develop connection evaluation criteria
      i. Durability
      ii. Ability to accelerate construction
      iii. Ductility
      iv. Ability to develop full strength and strain capacity of reinforcing steel
      v. Constructability
      vi. Maintainability
      vii. Reliability
      viii. Tolerances
      ix. Dependability
      x. Ability to field verify performance after installation
   b. Evaluate current connection details published in FHWA connections catalogue.
   c. Develop construction specifications.
   d. Develop Guide Specification for ABC and ultimately AASHTO bridge design specifications.
   e. Assess use of connections at different locations, including at the point of maximum moment, within the plastic hinge zone, in the elastic region, etc.
   f. Develop and agree upon standard shapes and details of bridge components including girders, columns, etc.
   g. Optimize girder cross-sections considering new high performance materials.
   h. Interact with appropriate AASHTO and TRB committees and industry groups including NSBA, NCBC, PCI, ASBI, etc.
   i. Develop guidelines for considering ABC in moderate to high seismic zones during the Type Selection process.
   j. Analytically assess the effects of seismic response by limiting or allowing joints to open in an extreme event.
   k. Develop Demonstration Projects and seek federal funding.
   l. Publish Standard Seismic ABC Details.
   m. Form Seismic ABC Technical Committee.

3. *Contract Elements*
   a. Early collaboration between Contractor and Designer

        i. Include Contractor on Design Team
        ii. Consider Design-Build contract partnership
        iii. Consider Design Sequence contract partnership
    b. Determine costs of project delays
        i. Public delay costs
        ii. Direct project costs
        iii. Escalation of funding costs
    c. Reflect Delay/Time Costs in Bid Process
        i. A+B
        ii. Incentive/Disincentive
        iii. Lane rental
        iv. Other

4. *Share Lessons Learned*
    a. Develop website dedicated to Seismic ABC information.
    b. Collect design and construction specifications used in other countries with moderate-to-high seismic hazards.
    c. Collect information on the performance of bridges with seismic ABC details during earthquakes or other extreme events.
    d. Share accelerated construction practices from other national and international agencies.
    e. Publish case studies.
    f. Hold workshops in other states sharing lessons learned.
    g. Review details used by others including railroad, building, offshore and international.

5. *Maintenance Issues*
    a. Assess ABC details and connections considering long-term durability and maintainability.
    b. Develop inspection practices for ABC details.
    c. Develop non-destructive evaluation methods and tools for ABC details.
    d. Collect long-term performance data from field applications of ABC details.
    e. Assess post-earthquake performance of joints opening in jointed precast members.
    f. Develop methods to rapidly evaluate post-earthquake damage and replace damaged ABC components.
    g. Assess potential corrosion issues including inspection and replacement of unbonded tendons.

APPENDIX A - Participant List

LAST	FIRST	EMAIL	AFFILIATION	POSITION
Beal	David	dbeal@nas.edu	NCHRP	NCHRP
Beauchamp	Mike	mike_beauchamp@dot.ca.gov	California DOT	Structure Construction
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Reno	Mark	markr@quincyeng.com	Industry	AFF20 - Steel Bridges Chair
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APPENDIX B - Program

ITEM NO.	START TIME	TOPIC	PRESENTER
1	7:30	Arrival and Networking	N/A
2	8:00	Welcoming Remarks – clarify workshop goals	Kevin Thompson
3	8:05	Agenda Review	Ray Wolfe
4	8:10	Meeting set-up	Mike Halverson
5	8:15	FHWA Perspective	Vasant Mistry
6	8:25	TRB Perspective	Stephen Maher
7	8:35	Update on nationwide state of practice and advantages	Mary Lou Ralls
8	8:50	An inventory of completed/ongoing ABC research	Ray Wolfe
9	9:00	Successful deployment of ABC	Bill Duguay
10	9:15	Questions and Answers	All
11	9:30	Break	N/A
12	9:45	Brainstorming; implementation of ABC in moderate-to-high seismic regions	Mike Halverson
13	10:45	Consolidate, categorize, and prioritize opportunities and obstacles	All
14	11:30	Break	All
15	12:00	Working lunch (breakout groups)	All
16	14:45	Break	All
17	15:15	Wrap up discussions, summarize needs and action plans	Session Leaders
18	16:30	Closing and Adjourn	Michael Keever
19	17:00	Steering Committee meeting convenes	Workshop Steering Committee
20	18:00	Steering Committee meeting adjourn	

APPENDIX C - Presentation Summaries

General Session Speaker Notes:

Workshop Overview –
Ray Wolfe (California Department of Transportation)

Accelerated Bridge Construction (ABC) techniques have evolved into proven solutions for bridge construction. Connection detailing for applications in regions of moderate to high seismic activity remains the one area needing additional development. This workshop focuses on these connection issues.

Welcoming Remarks: Movement of Goods and Services from Port to Border –
Kevin Thompson (California State Bridge Engineer)

The movement of goods and services on critical routes are vital to the economic interests on both a state and national level. Reducing delays to the traveling public coincides with the Department's One Mission/One Vision: "Caltrans Improves Mobility Across California". After a major event such as an earthquake, Caltrans must respond quickly and efficiently to restore mobility and goods movement. This accelerated delivery commitment necessitates accelerated bridge construction techniques and solutions to succeed.

Federal Highway administration (FHWA) Perspective –
Vasant Mistry (FHWA)

FHWA has been promoting the use of ABC techniques in an effort to combat construction-induced congestion by drastically reducing on-site construction time, provide safer construction site work environments for both the motoring public and the contracting forces, and standardize details to derive potential project cost savings.

Transportation Research Board (TRB) Perspective –
Stephen Maher (TRB)

TRB's interest in ABC stems from its mission of promoting innovation and progress in transportation: ABC techniques are presently evolving toward mainstream application. As a leader in national research problem development, management and information dissemination, TRB will play a key role in further developing the outcomes of the workshop into real implementable ideas and technologies. Highlights of TRB's completed, on-going and near future seismic and accelerated bridge construction research and coordination activities are briefly described.

Nationwide State of Practice and Advantages of ABC –
Mary Lou Ralls-Newman (Ralls Newman, LLC)

An overview of bridge construction projects that have been completed to date across the nation using accelerated techniques and the benefits and challenges of using these techniques will be discussed.

Seismic Connections for ABC Applications –
Ray Wolfe (California Department of Transportation)

Provides an overview of relevant research efforts underway at various academic institutions across the country. Key areas discussed include ductile behavior of connection details for precast segmented columns, energy dissipation and self-centering models.

Successful Deployment of ABC –
Bill Duguay (J.D. Abrams, LP)

A contractor's perspective: challenges owners, researchers and industry to develop repeatable, reliable, durable, and biddable connection details to facilitate ABC in moderate to high seismic zones. Simplicity and availability of specified technologies reduces risk. Contemplates contract vehicles as incentives for risk sharing and acceptance.

APPENDIX D - Brainstorm Ideas: All Inclusive

Categorization utilized in the table below:

A. Industry issues
B. Seismic
C. Substructure
D. Funding costs
E. Process
F. Foundations
G. Materials
H. PS&E

CAT/ NO.	BRAINSTORM IDEA
A1	Obstacles: Application of ABC techniques in urban setting – need for area for staging construction
A2	Obstacles: Availability of equipment needed to make heavy lifts of large prefabicated elements
A3	Obstacle: Contractor ways and means must be considered in developing strategy.
A4	Invite more contractor input. Convene another workshop with this group meeting with a similar number of contractors to discuss the issues Bill presented.
A5	Need to get general contractors in California to buy in and support ABC methods – and technologies.
A6	Industry guidance to designers – shipping limitations, fabrication capabilities, erection and on-site handling.
A7	Develop standardized bridge moving contract specifications.
A8	In regions like California, with a practice of cast-in-place concrete prevails, there should be incentive for contactors to seek ways to promote ABC. Design/Build cost incentives.
A9	Obstacle to clear: contractor inertia to cast-in-place
A10	Obstacles: Contractor willingness to take risks – we need early input on this, engage AGC or other methods to engage the industry on what risks they are willing to take.
A11	Need to collaborate the construction industry to develop more bridge footing specialty contractors, or expand the geographic areas the current moving contractors operate in.
B1	System tests and complex curved skewed bridges can provide realistic performance information of commonly found ABC bridge.
B2	Accelerated post-earthquake repair
B3a	The details on the PCI draft will be tested / evaluated for seismic behavior
B3b	Incorporate work of the PCI Bridge committee’s seismic subcommittee.

CAT/ NO.	BRAINSTORM IDEA
B4	Opportunities – draw on vast experience of PS precast industry. Obstacles: Develop ductile details for seismic.
B5	Do we have any evaluation of existing pre cast bridges that have been exposed to seismic ground motion in moderate or extreme seismic events?
B6	Segmental columns – pre cast post-tensioned connections in combination with using seismic isolation bearings in ABC
B7	Merge seismic requirements with AASHTO new specs for girders continuous for live load
B8	Obstacle – new seismic guide specs does not show acceptable pre-cast mechanisms.
B9	Performance based approach to system design – use performance based design methods for conventional bridges to design ABC bridges.
C1a	Obstacles / EQ resistance. Connection details that are: ductile/reliable - constructible (reasonable/field tolerances?) What if it doesn't fit?
C1b	Connections / tolerances and adaptabilities appropriate for actual steel conditions.
C1c	FABC- details of joint / connections need to be ductile and constructible.
C2	Use Corrugated metal ducts in tops of columns and bent caps to provide more tolerance in erecting.
C3	Connections: hybrids. Adopt ideas from buildings: tree construction and (bent caps integral with beam stubs); ductile steel building connection details.
C4a	Connections are an opportunity for allowing displacement and energy dissipation – common mindset focused on "monolithic" construction should be set aside.
C4b	Performance of connections and plastic hinge zones emulative of CIP or allow joints to open under extreme events.
C4C	Establish displacement capacity of segmentally constructed bridge piers for seismic design of ABC.
C5a	Connection – develop splices inside plastic hinge zones or develop ABC details to keep splices outside PHZ.
C5b	Need ductility test – and subsequent code recommendation for spliced connection at footing and bent cap.
C5c	Need ductility tests on connections similar to what has been done on traditional seismic connection.
C6	Development of dependable, easily constructed integral cap to column pre-cast connection would allow a designer to potentially pin column at the foundation, thus saving tremendously on foundation cost. Other than work done in NCHRP 12-67, 54, 12-74, we need to focus on this topic both from cost and performance perspective.
C7	Columns and stay in place forms
C8	The re center technology with strong ductile material will be beneficial for connection detail on bridge columns.
C9	Connections that utilize response modification devices (bearings, isolators, dampers.)
C10	Use of grouted splice couplers for emulation design connection.
D1	Contracting vehicle to drive ABC, evaluate traveler delay: const incentive /disincentive, A+B, other new concepts.

CAT/ NO.	BRAINSTORM IDEA
D2	Need some demonstration projects in high seismic regions where contractors work with owners to develop trial designs.
D3	How do you quantify the incentives / disincentives?
D4	A simple national methodology to determine delay-related user cost for a project.
D5	Need cost data developed for connection constructed elsewhere, with costs adjusted by region.
D6	Quantify all traffic control costs for a project.
D7	Develop consistent guidelines for costs / benefits evaluation to support ABC usage; i.e., lane rental rates.
D8	Opportunity: Reduced contract time, therefore reduced overload cost for consumer and agency.
D9	Opportunity – reduce time spent in a work zone reducing MPT costs and both safety hazards to motorists and highway workers.
D10	ABC should also focus on life cycle costs
E1	For ABC to be successful you need to change the culture of current participants involved in the process
E2	Perfect electronic submittals
E3	BIM technology for ABC Computer based tools for integrating design, manufacturing and construction. TEKLA?
E4	Is legislation or procurement method in place to support ABC? How does ABC fit with Caltrans mission and vision statement?
E5b	Should there be any reduction in QC/QA? On the other hand shouldn't we have an increased level of QC/QA at least as the concept evolves?
E5a	Does ABC inherently imply a minor compromise on established practice? Knowledge? Ex: Fly ash in concrete!
E6	Can details be made or developed to cover a wide range of applications? What plan is in place to communicate the need and desire to implement ABC from top to bottom of the organization and how about the other parties? GC's, producers, consultants and communities? What attitudes and assumptions need to be changed to implement ABC?
E7	Change involves a degree of product risk taking. How does a laterally organized organization obtain everyone's acceptance?
E8	Value stream map for ABC – provide a VSM for ABC to identify bottlenecks in design and construction process.
E9	Step-based design concept – enable optimal solutions by delaying final decisions until later in the design process.
E10	NOT requirements tools to evaluate state of members not otherwise visually feasible.
E11	Share info to address risks. Website, risk management plans, and case studies.
E12	Existing opportunity – do a synthesis of best practices, currently done by different states. This can end up as a toolbox of what has been done. The toolbox of what exists can develop into choices for the right tool (practice for the right project).

CAT/ NO.	BRAINSTORM IDEA
E13	How can design build processes be used and encouraged to solve simultaneously the seismic and constructability problems?
E14	S-ABC should be integrated with the whole ABC process – workable, fast, and safe.
F1	Footing to pile connection: develop connection details between columns and shafts or pile foundations.
F2	Connection detail for connection of pre-cast concrete cap with pre-stressed concrete pile.
F3	Development of integral abutments/piles/cap connections using grouted voids
F4	Use vertical P/T Bars to provide temporary connections to hold cap to column and serve as main vertical steel.
F5	Accelerate foundation construction - how can we develop appropriate accelerated foundation construction? Connection between piles, pile caps and columns.
F6a	Allow rocking motion at footing to dissipate energy and reduce demand at fixed footing / column interface.
F6b	Jacketed bottom: column piece hinge on top of spread footing.
G1	Innovative materials – New materials such as shape memory alloy might be good for SABC details.
G2	Determine long-term performance of ABC connections – durability, repair, long term monitoring under field conditions and inspection procedures.
G3	No material preferences. R/C is okay, but steel listed; composites (plastics) are to be considered.
G4a	Optimize and standardize components, consider high performance concrete/steel, and FRP materials
G4b	How can we best combine the characteristics of steel and concrete in ABC? Steel information management with concrete materials, use of both materials, and etc.
H1	Conduct system test. Develop standardized ABC system(s), and test them full scale.
H2	In urban areas with heavy car or truck traffic, why is precast, prestressed pavement used more often?
H3	Use the concept of concurrent engineering to develop bridge construction. Information system for ABC – general or for seismic applications
H4	Must develop design guidelines – examples and standardized details.
H5	Uniform piece weight girders /bent caps /columns /abutments
H6a	Connections for precast elements
H6b	Code recommendations for high seismic connections.
H7	Designers need to understand construction methods for precast/ABC

APPENDIX E - Brainstorm Ideas: Seismic Connection Detailing Focus

CATEGORY/NO.	RAW VOTE TALLY	CATEGORY	BREAKOUT GROUP ASSIGNMENT
B1	1	---	---
B2	6	A	1
B3[1]	2	D	1
B4	2	D	3
B5	2	D	2
B6	5	B	3
C1	8	A	2
C2	0	---	---
C3	5	B	4
C4	4	C	2
C5	2	D	4
C6	5	B	1
C7	0	---	---
C8	4	C	1
C9	0	---	---
C10	2	D	1
D2	5	B	2
E13	2	D	2
F1/F2 [2]	15	A	3
F3	5	B	3
F6	2	D	3
G1	5	B	4
G2	3	C	4
H3	1	---	---
H6	6	A	4

- [1] No action; pending publication of PCI seismic report.
- [2] Received the most votes, thereby rising to the top of the list.

APPENDIX F - Breakout Groups

1	2	3	4	COMMENTS
Mary Lou Ralls	Mike Keever	Stephen Maher	Ray Wolfe	Leader
Mehdi Saiidi	Jose Restrepo	John Stanton	Matt Tobolski	Academia
Bozidar Stojadinovic	Ian Buckle	Mark Veletzos	George Lee	Academia
Kevin Thompson	Richard Pratt	Paul Liles	Jugesh Kapur	DOT Rep
Lucero Mesa				DOT Rep
Michael Culmo	Steve Mislinski	Mark Reno	Doug Mooridian	Industry
Jon Grafton	Bill Duguay		Joe Tognoli	Industry
David Beal	Vasant Mistry	Harry Capers	Phil Yen	FHWA
Mike Beachamp	Paul Chung		Sue Hida	Caltrans
Elias Kurani	Mike Pope	Madhwesh Raghavendrachar	Tom Ostrom	Caltrans

APPENDIX G - Breakout Session Issue Template

Accelerated Bridge Construction Workshop
San Diego, Ca.
October 11, 2007

Group Number: ___
Idea Title: ____
Idea Number: ___
Group Leader: ________________________________

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A.	Provide a brief description of the idea. Where might it be implemented? What would it look like?
B.	Where/who/when was the idea used previously, if at all?
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)?
D.	If this idea is implemented, what is the desired outcome?
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them.

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San Diego, Ca.
October 11, 2007

Group Number: ___
Idea Title: ______________________________
Idea Number: ___
Group Leader: ______________________

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	
2	
3	
4	
5	

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)?

APPENDIX H - Populated Issue Templates

Accelerated Bridge Construction Workshop
San Diego, Ca.
October 11, 2007

Group Number: 1
Idea Title: Post-Earthquake Accelerated Column Repair/Replacement
Idea Number: B2
Group Leader: Mary Lou Ralls

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Develop accelerated methods to restore bridge to service after an event. Methods are both for temporary and permanent restoration.* *Implemented in moderate and high seismic zones.* *Would look aesthetically similar to existing columns.*
B.	Where/who/when was the idea used previously, if at all? *Steel jackets and carbon fiber jackets (wraps) have been researched.*
C.	Will this require additional work, research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Requires additional research on specifications for design and implementation.*
D.	If this idea is implemented, what is the desired outcome? *Product: post-earthquake rapid column repair/replacement procedures.* *Reliable/accepted design specifications and example. Established procedures result in quicker decision-making, which itself is an accelerated construction method.* *Widespread acceptance and use.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *See D above.* *Restored faster than conventional methods. Ability to resist aftershocks/new earthquakes.*

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Group Number: 1
Idea Title: Post-Earthquake Accelerated Column Repair/Replacement
Idea Number: B2
Group Leader: Mary Lou Ralls

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Review past work on (accelerated) repair/replacement (ARR) (not retrofit) methods.*
2	*Develop new ARR methods.*
3	*Select the most promising methods and investigate. Include construction industry.*
4	*Perform actual testing and evaluation.*
5	*Develop design specifications and procedure manual.*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)?

Accelerated Bridge Construction Workshop
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Group Number: 1
Idea Title: Investigation of Column Seismic Connections for ABC
Idea Number: C6/C8/C10 (combined)
Group Leader: Mary Lou Ralls

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Develop reliable connections that have not been researched previously for both cap-to-column and column-to-footing connections in moderate-to-high seismic zones. Include those identified in NCHRP-12-74; e.g., grouted splice couplers and re-centering techniques. Also consider the FHWA Connections Manual.*
B.	Where/who/when was the idea used previously, if at all? *Grouted couplers: tested by four states for bridge applications, but not considering high seismic concerns (NH, NY, MA, FL). Already used extensively in vertical construction. Other details identified in various states. Re-centering technology is in research stage for bridge construction. Other details in FHWA Connections Manual.*
C.	Will this require additional work, research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Research and design specifications (stress, strain, etc); worked examples. Verify coupler ability to develop ultimate strength and strain.* *Policy change: required for mechanical couplers and grouted splices (eg. Caltrans standard spec's permits only certain couplers) entails a policy change in the AASHTO LRFD specifications addressing staggered couplers.*
D.	If this idea is implemented, what is the desired outcome? *Products: connection details resulting in more options for designers; design specifications and examples.* *Widespread acceptance and use.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *Details meet accepted seismic performance requirements demonstrated by testing; eg. CA vs SC.* *Results in a construction process faster than conventional construction.*

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Group Number: 1
Idea Title: Investigation of Column Seismic Connections for ABC
Idea Number: C6/C8/C10 (combined)
Group Leader: Mary Lou Ralls

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Review past work including performance of existing details for these connections (e.g. NCHRP 12-54 and 12-74) under moderate and high seismic conditions. NCHRP 12-54 (steel integral cap with concrete column connection details). NCHRP 12-74 (precast concrete integral cap with concrete column connection details).* *Investigate technology transfer (vertical construction; welded caps used in railroad bridges).*
2	*Prioritize and further develop.*
3	*Select most promising methods.*
4	*Perform testing and evaluation.*
5	*Develop final product: design specs.*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? Include construction industry.

Accelerated Bridge Construction Workshop
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Group Number: 2
Idea Title: Response of Segmental Systems
Idea Number: C4a, b, & c and B5
Group Leader: Mike Keever

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Begin to look at a continuum on a case of connections where joints can open. Especially relevant to segmental construction. It should be looked as a continuum between purely jointed to monolithic.*
B.	Where/who/when was the idea used previously, if at all? *Has been done on individual columns, but not implemented on an actual bridge yet (for columns). Caltrans inverted-T design is allowed to open. Caltrans precast segmental so far designed to work as emulative.*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Additional research: inspection, removal of tendons, research needs to be done to solve long-term issues.* *Corrosion protection needed. Develop inspection guidelines.* *Identify examples where such jointed construction is likely to be used.*
D.	If this idea is implemented, what is the desired outcome? *For certain structures, joint opening can be very attractive. It depends on the performance level desired.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them.

Accelerated Bridge Construction Workshop
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Group Number: 2
Idea Title: Response of Segmental Systems
Idea Number: C4a, b, & c and B5
Group Leader: Mike Keever

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Workshop to address rocking/jointed systems and provide harmonized guidelines.*
2	*Workshop and presentation that addresses fundamental behavioral issues of jointed systems and compares with monolithic behavior.*
3	*Shake table testing of jointed systems and comparison with monolithic system.*
4	*Assess response of existing jointed/segmental bridges in past large earthquake events.*
5	*Monitor long-term performance of jointed systems for corrosion, maintenance needs; e.g., unbonded tendons.*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)?

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Group Number: 2
Idea Title: Connections – Ductile, Constructible, Rapid
Idea Number: C1b, D2, E13
Group Leader: Mike Keever

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Tolerances become tighter from the ground up. Tight tolerances are an obstacle. Details need flexibility so field corrections can be made easily. Details need to be as simple as possible and tested (lab tested). GPS instrumentation may be a potential tool to measure displacements. Connections must be constructible by field personnel. Connections must be able to be field verified. Performance, reliability, durability.*
B.	Where/who/when was the idea used previously, if at all? *WSDOT bends and hooks strands into bent cap – untested.* *NCHRP 12-57, Report 517, Example 2, "Plastic hinge in columns" – low tolerance (tested)* *NCHRP 12-74 Jose Restrepo*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? *Some level of research required (see F6)* Others (please specify)? *DOTs, researchers, contractors, industry need to work together for everyone's satisfaction. Physical testing would provide confidence that the connection serves its desired purpose. NCHRP 12-74 has a very well-rounded team that balances performance and constructability.*
D.	If this idea is implemented, what is the desired outcome? *Dependable, constructible, ductile, durable, inspectable, verifiable connections.* *Development of integral cap/column connections allowing huge savings in foundation costs.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them.

Accelerated Bridge Construction Workshop
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Group Number: 2
Idea Title: Connections – Ductile, Constructible, Rapid
Idea Number: C1b, D2, E13
Group Leader: Mike Keever

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow). *Subcommittee – DOTs, researchers, PCI, contractors form a work group.*

#	Planned Activities & Deliverables
1	*Develop a comprehensive list of viable ductile connections; determine which connections merit further investigation. Consider existing databases.*
2	*Physical testing . . .* *- Ductility (i.e. NCHRP 12-57)* *- Durability* *- Monitoring*
3	*Official guidance material, including connection details, must be comprehensive, and include design examples where applicable. Develop design guidelines to be approved by AASHTO.*
4	*Develop a ductile design that contractors cannot CRIP. Evaluate both short- and long-term performance.*
5	*Develop some demonstration projects in high seismic regions . . . contractors work together to develop trial designs. Close evaluation and feedback from all parties is essential. Seek Federal demonstration project funding.*
6	*Bring contractor on board early for the demonstration project. Compile comments from contractors before and during bid process. Conduct design charrette and compensate contractor for participation. Design-build contracts require legislation in some states. Not appropriate for demonstration projects since DOT's not directly involved - can't abdicate development work to design-build team. Design sequencing method allows DOT staff to work with contractor and academia on a demonstration project; may require legislation.*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? *Consider pooled funds (Western States?)*

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Group Number: 3
Idea Title: Segmental Post-tensioned Columns (Connections)
Idea Number: B6
Group Leader: Stephen Maher

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Precast post-tensioned connections using segmented columns.* *Same, with seismic isolation bearings.*
B.	Where/who/when was the idea used previously, if at all? *TX, NJ* *Puerto Rico – square columns* *FL – Sunshine Skyway segmental columns* *Circular post-tensioned columns tested at UCSD.* *Tests by S. Mahin at UC Berkeley.*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Research: Performance of round vs. rectangular* post-tensioned *columns.* *Confinement/armoring details at ends; round vs. rectangular.* *Policy: change*
D.	If this idea is implemented, what is the desired outcome? *Fabrication of circular* post-tensioned *segmental columns with performance/ductility properties equal to or better than conventional columns.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. - *Corrosion of tendons ~ inspection of ducts* - *Monitoring of creep* - *Seismic performance* - *Post-event verification (inspectibility)*

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Group Number: 3
Idea Title: Segmental Post-tensioned Columns (Connections)
Idea Number: B6
Group Leader: Stephen Maher

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Review* $\left\{\begin{matrix} \textit{research} \\ \textit{literature} \\ \textit{practice} \end{matrix}\right\}$ *on post-tensioned segmental concrete*
2	*Identify what can be extended from non-seismic to seismic applications with minor modifications.*
3	*Prepare research needs statement; include testing.*
4	*Integrate seismic requirements for post-tensioned segmental construction into specs*
5	*Develop construction details and inspection guidelines*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? *Especially contractors, precasters, and post-tensioning specialists*

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Group Number: 3
Idea Title: Footing-to-Column and Column-to-Foundation Connections
Idea Number: F1/F2
Group Leader: Stephen Maher

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Column to foundation connections. Many configurations are possible. Considered three: precast column to cast-in-drilled-shaft, column to precast pile cap to precast driven piles, precast pile extension to precast cap. See diagrams below. Used in CA, WA.*
B.	Where/who/when was the idea used previously, if at all? *Used previously for non-seismic applications in TX, NJ, GA, etc.*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Research: definitely* *Policy Change: possibly, depends on state*
D.	If this idea is implemented, what is the desired outcome? *A simple connection that is robust, repeatable, economical, constructible, and inspectable.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them.

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Group Number: 3
Idea Title: Column to Foundation Connections
Idea Number: F1/F2
Group Leader: Stephen Maher

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Obtain information from states about similar or related concepts presently used in non-seismic applications.* *Do a synthesis (to obtain information)*
2	*Develop research needs statement for new project, or add to existing project (12-74?)*
3	*NCHRP 20-7 task*
4	*Coordinate with industry in developing details.*
5	

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)?

Accelerated Bridge Construction Workshop
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Group Number: 3
Idea Title: Rocking Columns
Idea Number: F6
Group Leader: Stephen Maher

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Energy dissipation from jacketed segmental column through foundation. Include self-centering characteristics.*
B.	Where/who/when was the idea used previously, if at all? *New Zealand bridge and rocking wall research* *Tipping Mar + Associates building design* *Arup used rocking technology on the La Maison Hermes building in Tokyo*
C.	Will this require additional work, research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Perceptions and concerns of engineering community with a new idea*
D.	If this idea is implemented, what is the desired outcome? *Economical approach with sound engineering characteristics that will permit adoption of ABC.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *Post-event damage evaluation (especially corners of rocking element).* *(expected to provide easy assessment and minimal repair needs).*

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Group Number: 3
Idea Title: Rocking Columns
Idea Number: F6
Group Leader: Stephen Maher

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Look at applications in buildings and bridges in NZ to see what is possible, and synthesize findings.*
2	*Develop problem statement for applicability in US*
3	*Test scale models* *Run computer simulations*
4	*Report findings to AASHTO T-3*
5	*Note that this project shares many characteristics (e.g. rocking) with Idea B6 (Precast/Post-tensioned columns)*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? *MCEER, PEER, MAE Centers*

Accelerated Bridge Construction Workshop
San Diego, Ca.
October 11, 2007

Group Number: 4
Idea Title: Employ Connection Concepts From Other Segmentally Constructed Structures
Idea Number: C3
Group Leader: Ray Wolfe

Page 1 of 2

A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Learn from others how they develop connections for segmentally constructed structures* *Look to building industry as well as internationally*
B.	Where/who/when was the idea used previously, if at all? - *Building industry* - *Offshore* - *Railroads* - *International*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Hopefully we can simply implement ideas from others, but some research might be required specific to bridges.*
D.	If this idea is implemented, what is the desired outcome? *Cost effective designs, etc.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *Define performance measures based on the idea "adopted" from others.*

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Idea Title: Employ Connection Concepts From Other Segmentally Constructed Structures
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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	Synthesis study thru NCHRP – define available materials and properties, and recommend possible applications.
2	*Define research needs – NCHRP problem statement* *Others (pooled fund, FHWA, DOTs, Transportation Research Center,etc.)*
3	*Perform research / provide application recommendations*
4	*Trial implementation*
5	*Standardization (See code idea)*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? *See Section F*

Accelerated Bridge Construction Workshop
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October 11, 2007

Group Number: 4
Idea Title: Innovative Materials
Idea Number: G1
Group Leader: Ray Wolfe

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A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *Do not overlook possible advantages of new materials for ABC; such as shape memory alloys (SMA) and FRP.* *If implementable in any arena, could work for bridges.*
B.	Where/who/when was the idea used previously, if at all? - *Passive structural control theory applications* - *Mostly still in research arena* - *Perhaps look at applications in NASA and Department of Defense projects*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Anything and everything to become cost effective*
D.	If this idea is implemented, what is the desired outcome? *Efficient, durable, reliable, constructible, economical and maintainable structures.* *Paradigm shift: serviceability design for structures beyond simply life safety (reduce down time after extreme design event).*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *Emulative response until research okay's alternate approaches* *Jointed construction replication* *See "D" above*

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Group Number: 4
Idea Title: Innovative Materials
Idea Number: G1
Group Leader: Ray Wolfe

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Synthesis study thru NCHRP – define available materials and properties, and recommend possible applications.*
2	*Define research needs – NCHRP problem statement* Others (pooled fund, FHWA, DOTs, Transp. Research Center,etc.)
3	*Perform research / provide application recommendations*
4	*Trial implementation*
5	*Standardization (See code idea)*

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? *AASHTO T6* *See "F" above*

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October 11, 2007

Group Number: 4
Idea Title: Long-term Performance of SABC Connections
Idea Number: G2
Group Leader: Ray Wolfe

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A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *1 – Non-destructive evaluation tools* *2 – Research to address client needs with (accelerated) destructive environmental effects (testing to simulate 75 years of destructive environmental effects)*
B.	Where/who/when was the idea used previously, if at all? *Look at other industries and applications*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *Must focus on cost reduction* *Support long-term performance specs; Structural Health Monitoring (SHM)*
D.	If this idea is implemented, what is the desired outcome? *Important to garner support and confidence in industry to provide long-term in-situ non-destructive evaluation tools* *Improve predictable performance of bridges*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *The idea itself quantifies the performance measure of the specification*

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Group Number: 4
Idea Title: Long-term Performance of SABC Connections
Idea Number: G2
Group Leader: Ray Wolfe

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*This should not delay implementation of ABC: Look for SHM ideas ready to implement with previous full-scale (in-situ) test data*
2	*Perform synthesis study to identify SHM Tools for long-term performance validation – propose or recommend ideas* *Link to long-term bridge performance program (LTBPP)*
3	*Develop research problem statement to further studies on those ideas deemed cost effective and reliable alternatives from the synthesis study.*
4	
5	

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)? *AASHTO T18*

Accelerated Bridge Construction Workshop
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October 11, 2007

Group Number: 4
Idea Title: Code Recommendations for SABC
Idea Number: H6
Group Leader: Ray Wolfe

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A.	Provide a brief description of the idea. Where might it be implemented? What would it look like? *1 – This idea is the end result of research (cumulative).* *2 – It is the end result after testing and field verification. Codification ensures standardization.* *3 – Code provides measure of liability protection to engineer-of-record.*
B.	Where/who/when was the idea used previously, if at all? *Guide Specs (Seismic LRFD)* *"Quicker Structures" in the steel industry (railroad, buildings, & off-shore industries) – look at how construction is accelerated elsewhere*
C.	Will this require additional work: research, legislation, policy change (circle appropriate choices)? Others (please specify)? *AASHTO T3, T6, T10, T15 (walls, abutments)*
D.	If this idea is implemented, what is the desired outcome? *Detailed SABC guidelines promoting implementation of ABC in moderate-to-high seismic zones.* *Provide safe, reliable, consistent engineering.*
E.	Are there any performance measurement(s) you can suggest for this outcome? If so, please describe them. *Minimize complaints to AASHTO T3* *Details employed are repeatable, biddable, and constructible and reduce or preclude maintenance issues.*

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Group Number: 4
Idea Title: Code Recommendations for SABC
Idea Number: H6
Group Leader: Ray Wolfe

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F.	Preliminary action plan for subsequent consideration by the Steering Committee. Identify up to five steps or activities necessary for implementation (include details and be as specific as time will allow).

#	Planned Activities & Deliverables
1	*Securing funding sources – T3 should take the lead* *Pooled funds with FHWA and States*
2	*Identify research needs (TRB)/FHWA seismic research; perhaps coordinate internationally*
3	*Conduct appropriate research and manage properly to complete*
4	*Draft new chapters for AASHTO Guide Specs.*
5	

G.	Identify and recommend resources: organizations and individuals. Identify who needs to be involved in subsequent activity (Industry, FHWA, Universities, TRB, DOT's, AASHTO, others)?