CHAPTER 4 – SUMMARY OF RESPONSES TO THE QUESTIONNAIRE

A total of 15 responses were received. Two respondents were from different offices of the same manufacturer (Williams Form Engineering). Two other respondents were from closely affiliated companies, one a manufacturer (Friedr. Ischebeck GmBH) and the other a distributor (Con-Tech Systems, Ltd.). The replies of the respondents from these same or closely related entities were not always in agreement probably because practices might be different in the different geographical regions in which the respondents were located, e.g., North America and Europe and east and west coasts of the US.

A summary of all the responses is included in Appendix C. Since most responses were hand written, for the sake of clarity and uniformity all responses were reproduced in typed format. Also, in order to limit the number of pages in Appendix C, multi-lined responses were paraphrased by the authors and only the paraphrased versions, indicated by an asterisk, are included in the summary presented in Appendix C. Seven of the respondents were contacted for clarification of their responses. Appendix C includes the clarified responses. The original questionnaires and the full responses are available from CFLHD.

A summary of the responses, organized in the order of the questions in the questionnaire, is presented here. Information that was requested to be kept confidential by the respondents was omitted. Since not all the questions were answered by every respondent, in summarizing the responses only the "useful" answers are reported below, i.e., responses that provide a direct answer to the question being asked. Therefore, blank spaces and answers of "N/A", "?" or "-" were not counted because it is not clear whether those responses were due to a lack of experience with HBSNs or a lack of knowledge about a specific aspect of the question being asked. In some instances the respondents did not answer the question but provided a comment. These comments, although useful in themselves, are not included in this summary since they do not provide a direct answer to the question.

1. General Information

- Eleven of the respondents indicated that they had experience with both temporary and permanent HBSN applications to varying degrees. Respondents from state agencies, except for the California Department of Transportation (CALTRANS), seem to have had very limited or no experience with HBSNs.

- Of the fifteen useful responses, eleven respondents indicated that lack of corrosion guidance is a major impediment to their use of HBSNs, particularly in permanent applications.

- Of the twelve useful responses, eleven respondents indicated that if clear corrosion guidance was available they would consider using HBSNs more frequently.

2. Coatings

- Of the thirteen useful responses, seven respondents indicated that they use nails having purple marine epoxy coating with a common thickness of 7 to 8 mils (~ 0.18 to 0.20 mm), except for CALTRANS who indicated use of 12 mils (~ 0.30 mm) without specifying whether or not the bars are for permanent or temporary installations.

- Of the thirteen useful responses, three respondents indicated use of green epoxy coating with a common thickness of 3 mils (~ 0.08 mm).

- Of the thirteen useful responses, eight respondents indicated use of galvanization with thicknesses ranging from 4 to 10 mils (~ 0.10 to 0.24 mm). One respondent (Ischebeck from Germany) indicated use of a "combi-coating," which consists of an epoxy coating on bars that have been previously coated with 3.5 mils (~ 0.09 mm) of galvanization.

- Of the thirteen useful responses, four respondents indicated that they had experience with observation of exhumed nails. One of those respondents indicated that the epoxy coatings he observed had been damaged.

3. Use of Sacrificial Steel

- Of the fourteen useful responses, seven respondents indicated that they used sacrificial steel.

- Two respondents indicated that they assume approximately 63 mils (~ 1.6 mm) for loss of steel section. One respondent indicated the use of one bar size larger than the size required by design.

4. Grout

- There were nine useful responses regarding the typical thickness of grout cover over the bar. The range of grout cover thickness was reported to be 0.75 to 3.0 in (~ 19 to 75 mm) with seven of the nine responses being in the range 1.0 to 2.0 in (~ 25 to 50 mm).

- There were nine useful responses regarding grout strength with reported values ranging from 3,000 to 6,000 psi (~ 20 to 40 MPa).

- There were ten useful responses regarding the cement type. Three of the respondents indicated use of Type I cement and four indicated use of Type I/II (general purpose) cement. One respondent indicated use of Type K (non-shrink) cement while two respondents indicated use of Type III (high early strength) cement.

- There were nine useful responses regarding water:cement ratio with values reported to be between 0.40 and 0.50. Six of the nine respondents reported a value of 0.45.

- There were ten useful responses regarding mixer type. Eight of the ten respondents indicated use of a high speed-high shear colloidal mixer for preparation of grout. One respondent indicated use of paddle mixers and one respondent reported using both types.

- There were ten useful responses regarding the use of diluted grout (flushing grout) for initial drilling and full strength grout (final grout) once target depth was reached. Six of the ten respondents indicated that they use both. Two respondents indicated use of full strength grout throughout the drilling process. One respondent indicated use of full strength grout throughout the drilling process in soil, and water for initial drilling in rock. One respondent reported that usage varies with soil type.

5. Evaluation of Soil Corrosivity

- There were seven useful responses regarding the use of assumptions or data for evaluating soil corrosivity. Three respondents indicated that they make assumptions; three indicated that they do both, and one respondent uses data only.

- There were nine useful responses regarding the use of guidance in GEC #4 (FHWA, 1999). All respondents indicated that they do not use GEC#4 (FHWA, 1999).

- There were ten useful responses regarding the use of guidance in GEC #7 (FHWA, 2003). Five respondents indicated that they used GEC #7 (FHWA, 2003) and five indicated that they did not.

- There were nine useful responses regarding the use of other guidance. Two of the nine respondents indicated use of the German standards (DIN [Deutsches Institut für Normung], 1985) for evaluating corrosion, one respondent used personal experience based on mechanically stabilized earth (MSE) walls, one respondent used the guidelines of the Post Tensioning Institute (PTI, 1996), one respondent used guidance on culvert criteria, and one respondent used guidelines in the Manual for Design & Construction Monitoring of Soil Nail Walls (FHWA, 1996).

6. Field Corrosion Testing Program

- There were thirteen useful responses regarding field corrosion testing. Of the thirteen respondents, seven had not performed a field corrosion testing program. Two respondents indicated that they had performed a field testing program and referred to an on-going field testing program in Switzerland. One respondent referred to an ADSC/FHWA field testing and exhumation program in Salt Lake City, and another respondent indicated an on-going ADSC study. The other two respondents that reported

having conducted field corrosion tests did not comment about them. Final reports were not available for any of these studies.

7. Laboratory Corrosion Testing Program

- There were thirteen useful responses regarding laboratory corrosion testing. Of the thirteen respondents, ten had not performed a laboratory corrosion testing program. Two respondents indicated that they had performed a laboratory testing program and referred to an on-going testing program in Switzerland. The final report on the Swiss study was not available.

8. Effect of Thread Type/Configuration

- Thread type/configuration was singled out in the questionnaire even though it is just one of many factors that could influence crack development such as: the non-uniformity of the grout body, soil type, nail load, ground stresses within the finished reinforced mass, couplers, centralizers, etc. From the way the question was posed in the questionnaire, there were thirteen useful responses regarding the effect of thread type/configuration on corrosion rates. Nine of the thirteen respondents indicated that they did not think thread type (the R-thread versus the sharper thread) made a difference in corrosion rates. Two respondents (Con-Tech and Ischebeck), indicated otherwise and referred to studies done in Germany, which indicate that the sharper CTS/TITAN type threads reduce crack widths in the grout body thereby offering better protection against corrosion. One respondent answered affirmatively but indicated that the data show no difference in the cracks. One respondent answered affirmatively but had no data to support that answer.

9. Encapsulated HBSNs

- There were thirteen useful responses regarding awareness of encapsulated HBSNs. All but four respondents were not aware of encapsulated HBSNs.

- There were eleven useful responses regarding the feasibility of encapsulated HBSNs from an economic and construction viewpoint. Seven of the eleven respondents indicated that encapsulated HBSNs are likely not economically feasible or constructible. The four affirmative respondents conditioned their responses with comments regarding application and construction techniques e.g., the use of short lengths of encapsulated HBSNs near the face of the wall to mitigate corrosion near the nail head location.

10. Drill Bit Size and Centralizers

- There were nine useful responses regarding drill bit size. Six of the nine respondents reported values for the drill bit: HBSN OD ratio ranging from 1.6:1 to 4:1. Two respondents indicated use of drill bit sizes that were 2.0 in (~ 50 mm) larger than HBSN outside diameter (OD) for sand and 3.0 in (~ 75 mm) larger than HBSN OD for gravels.

One respondent indicated that the size varies by bit type and/or manufacturer, e.g., 3.0 in (75 mm) to 6.0 in (150 mm) for R38 bar.

- There were eleven useful responses regarding the use of centralizers. One respondent reported that they do not use centralizers. Seven of the remaining ten respondents reported use of centralizers on from 50 to 100% of their jobs. One respondent did not use centralizers on all projects and one indicated they use centralizers only when required. One user expressed concern about metal centralizers damaging the epoxy coating during installation of the soil nail. As indicated in Chapter 2 under the discussion of grout cover, drill bit size and centralizers, there is a need to develop centralizers made from durable non-metallic materials (e.g., thick nylon) that can withstand the extreme conditions imposed on the bar and centralizers during the installation of HBSNs.

- There were seven useful responses regarding distance between centralizers. Five respondents indicated 10 ft (3 m), one respondent reported a range of 8 ft (2.5 m) to 10 ft (3 m), and one respondent indicated 5 ft (1.5 m).

11. Other Corrosion Studies

- Of the fourteen useful responses regarding awareness of other corrosion studies, eight of the respondents were unaware of other corrosion studies. One respondent referred to an NCHRP proposal for research on the use of HBSNs for slopes or walls, but after follow-up discussions with the respondent it was found that the research was not funded. Three respondents referred to studies in Europe. One respondent referred to the PTI recommendations for anchors. One respondent referred to an ADSC/FHWA study by Schnabel Engineering.

12. Additional Input and/or Suggestions

Eleven respondents provided additional input and/or suggestions. These responses are a combination of recommendations and concerns. When taken together they provide a sense of the respondents' expectations from FHWA regarding corrosion guidance. They are presented here almost verbatim for the sake of accuracy. Where similar suggestions or comments were made by multiple respondents, the suggestion that was worded most clearly is reported.

- Follow German criterion that requires a minimum of 35 mm (~ 1.4 in) of grout cover for permanent soil nail applications. This criterion does not apply to HBSNs used as compression members such as micropiles.

- Use the sacrificial steel method.

- Consider using stainless steel for aggressive ground conditions.

- Be careful while dealing with the corrosion issue. Biggest concern is installation damage of any coating. Starting to see a number of MSE wall failures due to corrosion of steel reinforcements.

- Use combi-coating (epoxy-coated galvanized bars) for permanent applications in non-corrosive soils. HBSNs should not be used in aggressive, corrosive soils for permanent applications. The level of soil aggression must be well established by ASTM and CALTRANS standards.

- Need specific guidance because currently some users ignore corrosion while some suppliers/users promote sacrificial steel.

- Ensure drill bit is at least 1.5 in (~ 38 mm) larger than bar diameter.

- Use HBSNs only in non-aggressive ground.

- Use galvanized coating instead of epoxy coating from a durability standpoint since galvanization is a sacrificial coating.

- Need to develop better understanding of the size, shape and quality of resulting grout column for the proper selection of design assumptions for permanent wall design. Evaluate if there is a build-up of cuttings at the couplers, with or without the centralizers that will create porous pockets for increased corrosion there. Evaluate if there is a shrink sleeve durable enough to protect the couplers and threads on the bars adjacent to the couplers after installation.

- Need to be careful with use of metal centralizers since they would damage the epoxy coating during installation.