final report

Offshore Runway Construction Concepts

Blue Ribbon Panel Review

November 15, 2000

FINAL REPORT

SAN FRANCISCO INTERNATIONAL AIRPORT

OFFSHORE RUNWAY CONSTRUCTION CONCEPTS

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The San Francisco Airport Commission ("Commission") is considering the reconfiguration of the runway platforms at the San Francisco International Airport ("SFO"). To assist in understanding the choices the Commission faces, it assembled a panel of individuals who are highly experienced in the engineering and construction of marine structures, the "Blue Ribbon Panel" or "BRP". This Report summarizes the Commission's Blue Ribbon Panel observations of five (5) Consultant study proposals of three (3) structural concepts for the three (3) runway platform configurations. These concepts and study proposals are supported by additional information provided by the Airfield Development Engineering Consultant (ADEC), who is under contract to the Commission. The observations are intended to assist the Commission in making a selection of the concept(s) that will be used for the possible future runway platform reconfiguration.

The design and construction process for the runway platform reconfiguration for the San Francisco International Airport presents an extremely challenging task to arrive at a design that presents the best overall solution for achieving new runway platform development while balancing environmental and financial objectives with design and operational requirements. There are a multitude of design, construction, operational, environmental and financial parameters and conditions that will influence the final design. In several areas, conflicting requirements will need to be addressed for any final selection. Critical issues and requirements need to be prioritized and evaluated, including environmental impact, seismic performance, operational requirements, cost, inspection and maintenance, structural reliability, and ease of inspection, maintenance and repair. Some key site issues are (1) keeping to a minimum the impact on existing air traffic operations, (2) meeting the seismic design requirements for this project, with the objective to have runways operational within 90 days of an ultimate level event (magnitude of 8.0 earthquake on the San Andreas Fault), (3) the effects from the significant depths of unconsolidated Young Bay Mud (YBM) that underlie the new runway platforms, (4) the location of suitable dredged material sources for fill and areas for the disposal of overburden and unsuitable material, (5) minimizing local water quality changes (both short and long-term), and (6) meeting air quality requirements during construction.

The three (3) basic structure concepts included in the five (5) Consultant study proposals are: (1) earth fill structures (EFS) similar to those that currently exist at the San Francisco International Airport, (2) various design and construction methods of pile-supported structures (PSS), and (3) a float-in, bottom-founded structure (BFS).

The earth fill structures as proposed consist of the placement and compaction of an estimated 25 million to 50+ million cubic yards of dredged material consisting of fine to coarse graded sands. The actual quantity is dependent upon the runway platform configuration selected and design requirements adopted. The perimeter containment of the fill structure as proposed consists of either an engineered rock fill or steel sheet pile structure. Some earth fill structure construction is also required for portions of the pile supported structure and bottom-founded structure concepts.

The pile supported structures proposed consist of several options as described within three of the five consultant study proposals. Several thousand vertical piles support precast, prestressed concrete runway platform deck units. The piles proposed are 4'- 0" diameter steel piles, 7'- 0" diameter reinforced precast concrete piles, or 10'- 0" diameter cast-in-place reinforced concrete piles. The pile spacing ranges from 40 feet to 81 feet each way. The reinforced concrete deck units are cast off-site and transported to the project by barges. Piles extend down to 200 feet or more below the mudline.

The bottom-founded structure consists of precast modular units (117' x 117') that consist of a bottom concrete slab 1'- 6" thick with 4'- 0" diameter reinforced concrete columns at 30 feet on center, that support the concrete deck section of the unit. Modular units are water-transported to the site and placed on a 5' - 0" thick gravel base.

All of the three (3) structural concepts are feasible to construct under the construction methods prescribed with appropriate design revisions. However, with each design concept and construction method, there are distinct advantages and disadvantages, relative to operational benefits, cost effectiveness and environmental compatibility. The final selected design may well be a combination and enhancement of these various design concepts and construction methods that best balances the overall benefits to the Bay Area and aviation community.

This Report describes the credentials of the BRP and the process that the Commission used to select the five (5) Consultants who studied the various concepts. For the purposes of evaluating the concepts and providing assistance to SFO in the selection of solutions for the Airport expansion, the BRP established four (4) guiding principles that were applied to all of the concepts. These principles have been selected as a result the experience of the BRP, applied to the information contained in the Consultants' reports, the ADEC reports, and other information furnished by the Airfield Development Bureau (ADB). The four (4) principles and associated issues are designed to provide "Best Engineering and Construction Practices" to assist the Commission in selecting a runway platform solution(s) that would best serve the needs of the Airport. A summary of the guiding principles and issues are as follows and are described in more detail in the body of this report:

1. **Minimal Environmental Impact**
    - Dredging and In-Bay Disposal
    - Sedimentation
    - Water Currents
    - Air Quality
    - Mitigation
2. **Ensure Seismic Safety and Functionality**
    - Diversity of Seismic Response
    - Functionality after Seismic Event
    - Reliability

- Inspection and Repairability
- Minimize Risk

3. **Minimize Impact on Airport Operations**
   - One Type of Structure Per Runway
   - Ease of Inspections
   - Utilities – Initial Installation and Ability to Re-configure
   - Durability and Maintenance
4. **Optimized Cost and Schedule**
   - 4-5 Year Construction Schedule
   - Diversification in Contracting
   - Diversification of Labor and Material
   - Initial Development

Applying these four (4) principles and corresponding issues to the five (5) Consultant study proposals and the various design and construction methods proposed, the following observations were made:

<u>Earth Fill Structures</u>:

- Least cost of all three (3) concepts.
- Has environmental issues, including water circulation, sedimentation, air pollution and other negative environmental issues.
- Has fairly long construction schedule due in part to the time need to consolidate the soils under the runway platforms. Also, the permitting process to obtain fill and disposal of dredged material could delay start of construction.
- Needs a containment structure around perimeter of fill area to be constructed prior to the dredge filling operations. Containment structure must be stable under static and seismic conditions.
- Fill of appropriate materials must be adequately compacted to eliminate liquefaction under a major seismic event.

- Gradations and quantities of existing sand sources proposed for fill may not be ideal. Needs further study.
- Easiest of all concepts to inspect and repair.
- Seismic damage would occur only in localized areas.
- Runway platforms can maintain relatively constant elevations over the entire length, including taxiways and connections.
- Finish grade is elevation 7.5 feet NGVD for fill structure compared to proposed elevations of 23.5 feet NGVD for the pile structure concepts.

Pile Supported Structures:

- More costly than an earth fill structure.
- Piles should be concrete for durability (precast or cast-in-place).
- Pre-design load test study of piles are needed (vertical and lateral).
- Feasibility of casting in place large diameter concrete piles in YBM must be demonstrated.
- The minimum pile spacing should be not less than 40 feet each way to allow adequate water flow and minimize sedimentation. Shoaling and sedimentation with time may minimize the perceived benefits. (Needs further study).
- Limits of long term settlements of the pile supported structure need further definition.
- Existing precasting production facilities in the Bay Area will have to be supplemented.
- Damage to the structure in a major seismic event must be limited to a location in the pile where it can be inspected and repaired within an acceptable time scale. Provisions for ease of inspection must be incorporated in the design.
- In a major seismic event, damage to structure must be limited to upper sections of pile and must not cause damage or displacement to the deck.
- The structure should minimize expansion joints. Joints should be designed for seismic performance and ease of repair.

- Protective coatings or high-performance concrete will be needed in those areas of the superstructure that are in the splash zone (area of structure exposed to tidal fluctuations and wave/swell action).

Bottom-Founded Structures:

- More costly than an earth fill structure.
- Provides the best overhead clearance during construction.
- The differential and long-term settlements of the bottom-founded structure need further evaluation and consideration in the design.
- Existing precasting production facilities in the Bay Area will have to be supplemented for the duration of the project.
- Initial perceptions are that, in the short term, the water circulation and sedimentation in the Bay is somewhat impacted by bottom-founded structures, but questions exist about the long-term effects and must be studied. The bottom-founded structures, with proposed column spacing of 30 feet, is considered less favorable for water circulation and sedimentation than the pile supported option.
- Damage to the structure in a major seismic event must be limited to a location in the supporting columns where they can be inspected and repaired within an acceptable time scale.
- There is some seismic uncertainty about the performance of this type of structure and the proposed function of the gravel layer as seismic fuse. This must be studied.
- Concerns exist about the lack of continuity of the bottom slab of the structure. Perhaps additional studies in this regard can solve the problem.
- Protective coatings or high performance concrete will be needed in those areas of the superstructure that are in the splash zone (area of structure exposed to tidal fluctuations and wave/swell action).

From a cost and stability standpoint, the earth fill structure has several advantages. However, if environmental issues become the overriding factor, the pile supported structure or bottom-founded structure may be more advantageous.

The final selection of runway platform configuration and structure type could be a composite of several of the design concepts and construction methods that were developed. This would put less strain on the specialized resources in the Bay Area, minimize environmental impact, allow concurrent construction activities, thus improving the overall construction schedule, and collectively spread the seismic risk of the entire facility. Technical issues and details to be considered for the final design of the different structure concepts, as well as proposed structure concepts for the various runway configurations based on environmental constraints, are discussed in this report.

INTRODUCTION

The Blue Ribbon Panel (BRP) was created and first convened in December 1999 at the direction of the Commission by the SFO Airfield Development Bureau (ADB). Panel members were selected based upon broad and diversified experience and specialized expertise related to extensive design and construction knowledge and experience for both major marine construction and airfield development. The panel consists of seven members: Dr. George C. Hoff (Chairman), Mr. John Azeveda, Mr. Reinard Brandley, Dr. Frieder Seible, Mr. Owen Miyamoto, Dr. Graham Plant, and Mr. Alfred A. Yee. The qualifications and experience of each panel member is furnished in attached brief resumes (Appendix A). These individuals are recognized within the national and international engineering and construction community for their collective knowledge, contributions and achievements involving large marine construction projects, including offshore drilling platforms; seismic design, construction, and retrofit of buildings and bridges; new airfield and runway development; coastal structure construction and repair; dredging; pre- and post-tensioned concrete structures; and new technology development. The members of the BRP collectively possess an exceptional breadth of experience in designing, engineering and constructing many of the major marine structures developed throughout the world over the past 30 years. The BRP, thus, has had first hand experience with the practical challenges and solutions in engineering and construction of marine structures like the proposed runway reconfiguration, using many different approaches, and under many different conditions.

The formation of the BRP provides SFO with an independent, high level engineering and construction overview of the various proposed concepts for the SFO developed runway platform configurations and locations. The review process, described herein is not intended to select the final runway platform structure type and configuration, but to identify and evaluate the advantages and disadvantages of various proposed structural systems with regard to their design, construction, environmental impact and operational aspects. The review highlights potential benefits, identifies the shortcomings of each study proposal, and provides guidance and criteria to the Commission for their selection of design criteria that best balances the airport operational goals, seismic performance objectives, and funding resources - all within the Bay Area environmental requirements.

Prior to the formation of the BRP and concurrent with its existence, the ADB and its consultants developed a significant amount of preliminary study material related to the proposed runway platform expansion. A feasibility study of various runway platform configurations was developed by URS Greiner and was issued March 1999 (not part of the BRP review material). This information and data are related to areas of environmental concerns, including water and air quality, borrow and fill site conditions, possible wetland creation, a considerable amount of geotechnical data and hydrological study information, and cost estimate evaluation. There were also numerous reports and analyses developed by the Airfield Development Engineering Consultant (ADEC). This information was provided to the BRP to assist in their deliberations.

BRP PROCESS

The Commission is seeking a broad range of feasible design and construction options for the development of offshore platforms for possibly reconfiguring SFO's runways. The Commission's objective is to establish an open process that will encourage the engineering and construction community to engage their creativity, experience and talents to submit their best ideas and concepts for constructing platforms for reconfigured runways at SFO. To accomplish this, SFO issued a Request for Qualifications (RFQ) on January 7, 2000, to the international community of engineers and construction contractors. The RFQ described the construction challenges facing the Program, and the criteria for selecting qualified firms. Pre-Submission of Qualifications (SOQ) meetings were held by SFO to further describe the program and answer questions. Prospective qualifiers were also given the opportunity to submit written questions or requests for clarification. All SOQ's were required to be submitted by January 31, 2000. Fourteen (14) proposals were received.

The next step in the process was to review the submitted Statements of Qualifications in order to narrow the competing firms to those that best met the requirements of the RFQ. To accomplish this, the BRP reviewed all the SOQ's and ranked the submittals in a manner to assure that all reasonable solutions were to be considered. The proposals were evaluated relative to (1) project concepts, (2) project approach, (3) qualification and experience of staff, and (4) qualifications of firm and experience with similar projects. Of the fourteen (14) submittals, nine (9) were determined to be responsive to the solicitation. Unproven technologies were considered non-responsive.

The third step in the process was to issue a Request for Proposal (RFP) dated February 15, 2000, to the nine (9) firms selected to more fully develop their study proposal concepts for the runway platform design and make an oral presentation to the BRP and SFO staff. The RFP submittal was due March 2, 2000. One organization failed to meet the SFO deadline for submittals and was considered as non-responsive and their proposal was not accepted. Presentations of the other eight (8) proposals were made to the SFO and BRP on March 8 and 9, 2000.

The BRP then evaluated the proposals and ranked them. From that ranking, five (5) proposals were selected for further development. These proposals included a variety of engineering and construction solutions. The five (5) firms, including joint ventures, were:

- Peratrovich, Nottingham and Drage, Inc.
- The Dutra Group, Hydronamic, bv., and BeanStuyvesant LLC (DHB)
- AGS, Inc.
- Parsons Brinckerhoff Quade & Douglas, Inc.
- T.Y. Lin International; Ben C. Gerwick, Inc, Han-Padron Associates, a joint venture.

Each firm, hereafter called "Consultant," was awarded an identical lump sum contract by the SFO for the preparation of design concept study proposals for three (3) runway platform configurations.

The final submittal and review process included:

- In May and June, the selected Consultants made partial progress submittals.
- Based on the partial progress submittals, ADEC furnished some specific design issues for Consultants to incorporate into their presentations.
- All final submittals of the Consultants' work were due on July 24, 2000.
- BRP given all proposal packages to review on July 25, 2000.
- BRP convened in private session in Burlingame, California, August 20, 2000, to discuss and consolidate issues, and formalize questions for the August 21, 2000, presentations.
- On August 21, 2000, each Consultant made a one-hour presentation of its report to the BRP, SFO and the other four (4) Consultants. Each presentation was followed by 30 minutes of questions and answers from the BRP.
- On August 22, 2000, all Consultants were invited for an open discussion of related issues that they felt needed additional review. This included comments by each of the Consultants on the proposals submitted by the others, which assisted in better identifying some of the differences among the proposals.
- On August 23-24, 2000, BRP convened independently to deliberate on the proposals, presentations and open discussions, and to initiate consolidation of their individual observations and findings.

SCOPE OF BRP REVIEW

This section describes the BRP's review of five (5) Consultant study proposals for three (3) different structural concepts with three (3) runway platform configurations. Based on the information contained in these consultant concept reports, along with other study information provided by ADB and ADEC, the BRP's collective findings and observations or potential benefits and problems for each concept and proposal study, as they relate to design, construction and operation, are presented. The intent is to provide essential design, operation and construction requirements so that the Commission will be better positioned to integrate construction and engineering considerations with environmental and financial factors, to arrive at the optimum project solution.

It is not the intent of the BRP to go into the considerable volume of detailed and supportive information developed for this project, but to take a broad approach to highlight and summarize the more significant and governing design, operational and construction requirements within the five (5) Consultant concept studies. The background information, analysis and summaries provided by ADEC have been taken into account by the BRP for this analysis.

OVERVIEW OF PROPOSALS

The Commission had provided the Consultants with Airfield Layout Plans for three runway configurations. These plans were based on feasibility studies previously conducted for the Commission. Each plan proposes the construction of a platform 1,100 ft. to 1,500 ft. wide, on which will be constructed the runway/taxiway complete, consisting of one runway, one or two taxiways, safety areas, object-free areas, and service roads.

The Airport Layout Plans considered in these studies are designated as runway configurations A3, F2 and BX-refined and are presented in Appendix B. These plans include the following development (these are the approximate runway lengths used for the BRP review):

- Alternate A3 – Alternate A3 provides for one new 11,500-foot runway (10L-28R) plus associated taxiways. Also included are minor extensions to the Runway 10R-28L complex and additional taxiways to serve existing runways.

- Alternate F2 – Alternate F2 provides for two new runway complexes and the extension of the other two runway complexes. New runways will include Runway 10L-28R, approximately 11,500 ft. long, and Runway 1L-19R, approximately 11,500 ft. long. Runway 1R-19L will be extended approximately 5,450 feet, and there will be minor extensions to the Runway 10R-28L complex. Additional taxiways will be constructed to serve existing runways.
- Alternate BX-Refined – Alternate BX-refined provides for the construction of two new runways and the extension of two existing runways. New Runway 10L-28R is approximately 11,500 ft. long. New Runway 1R-19L is approximately 8,600 ft. long. The extension to Runway 1L-19R is approximately 7,150 ft. long. The additions to Runway 10R-28L will be minor. Additional taxiways will be constructed to serve the existing runways.

Each Consultant was asked to develop their particular design concept proposal for these three (3) runway platform configurations. Their proposed designs were to meet the demanding requirements for completion within 4-5 years from commencement of construction; two level seismic design and performance, including a maximum 90-day repair time when damaged by the ultimate level earthquake (ULE); settlements in the YBMs; meeting aircraft loading and operational requirements; and minimization of environmental impacts relative to water quality (both in the area immediately adjacent to the airport, as well as dredge disposal and borrow areas). Also, during construction local air emission limits must be adhered to or appropriate mitigation measures taken. The requirements from the Request for Proposal are contained in Appendix D.

A brief summary of the five (5) Consultant proposals are as follows (in no particular order) - quantities are approximate and will be refined when final engineering is accomplished (refer to Appendix E for drawing):

PERATROVICH, NOTTINGHAM AND DRAGE, INC.

The concept is a dredged fill runway platform structure with perimeter support by open cell steel sheet pile walls (80' deep) with tail wall extensions. Wick drains are used for

- Sedimentation - It is essential to know the water quality circulation details, including sedimentation rates and possible shoaling locations.
- Water Currents – Closely related to sedimentation issues, studies need to be concluded to determine impacts of each concept on water currents.
- Air Quality - The air emissions of equipment during construction need to be controlled and minimized to meet Bay Area emission standards.
- Mitigation – There will be environmental impacts associated with any of the proposed concepts. Available environmental mitigation options need to be evaluated to provide the best overall solution for achieving and maintaining environmental objectives.

2. **Ensure Seismic Safety and Functionality**
   - Diversity in seismic response - The various concepts will experience different levels of damage under severe earthquake loading. A mix of different runway platform types will reduce the risk that all runways will be made inoperable at the same time.
   - Functionality after seismic event – Meet airport operational requirements
   - Reliability – Provide a robust structural system which can decouple the seismic response from the unknown seismic input.
   - Ease of inspection and repair - The runway platforms should be designed to make inspection and any subsequent repairs accessible and easy, following a major seismic event, without extensive service interruptions.
   - Minimize Risk - Sufficient in-situ sampling and testing must be done prior to final design and construction to be certain of structure performance especially as relates to settlements and seismic displacement capacities.

3. **Minimize Impact on Airport Operations**

   It is critical to not disrupt or interfere with airport flight schedules and to comply with all FAA safety regulations. Areas of specific focus are elevation clearance restrictions, which may limit pile driving operations and work areas. Also, the transport of labor and materials should be coordinated so as to minimize the impact on road traffic surrounding airport.

- One type of structure per runway - For example, a proposed runway platform could be all fill or all piles, but not a combination of the two. This eliminates undesirable transition structures and reduces possible differential settlements.
- Durability and maintenance - It is essential to integrate long-term durability issues into the design process in order to attain a 100-year service life of the structure. This could include coatings of steel reinforcement, durable high strength concrete with the appropriate admixtures, focus on added protection for material in the splash zone, (i.e. coating of piles, etc.), strategic location of seismic plastic hinges to minimize damage and provide for ease of inspection and concrete repair, cover of rebar, as well as ease of access and maintenance for all critical connection areas.
- Type of runway surface - Because of continuing settlements of any structure built on YBM, the potential for damage to a rigid pavement with time and during a major seismic event, and due to the required flexibility to move lighting in the pavement surface as the airport evolves over time, the paving surface should be flexible.
- Accommodation of utilities – The lighting and navigational aids will require power and signal cables. Designs must also consider and accommodate the airfield operation changes in utility arrangements over time. These items can be routinely handled for the fill structure but may require special consideration for the pile or bottom-founded structures.

All runway concepts must adequately provide for the collection, treatment and disposal of airfield rain water run-off. Also, the requirements for any fire and sea rescue facilities need to be considered in the airfield design.

4. **Optimize Cost and Schedule**

- Four to five year construction schedule: Typically, the more a schedule is compressed, the more the costs increase. The reasonableness of the current

Airport proposed schedule (complete F2, BX-refined in less than 5 years – complete A-3 in less than 4 years) must be balanced against the costs the Airport is willing to incur.

- Diversity of labor and materials resources: If more than one runway platform is built, a mix of runway platform structure types should increase competition, reduce the demand on given skills and trades, and reduce the pressure on local material resources. It reduces the risk of shipping and fabrication delays for the project and provides for concurrent on-going construction and greater flexibility in schedule.
- Diversification in contracting methods: Allowance for multiple contracts for different structure types or runway platforms should result in greater competition, resulting in lower cost and spreads contracting risk. Lump sum and unit price items must be carefully identified. "Best Value Contracting" methods and not only low bid, should be considered.
- Initial Development: In the pre-Project Planning, carefully review design alternatives, evaluate environmental impacts, and consider both initial construction costs and long-term operations and maintenance costs.

FINDINGS AND ISSUES

Given sufficient time and money, and ignoring outside considerations, such as environmental impact during and after construction, all of the runway platform concepts proposed can be used to develop the runway platform reconfiguration. However, it is important to be sensitive to environmental issues, seismic structure performance, having finite budgets, definite times when the new runways are needed, and many external constraints (some not yet being well-defined). In Appendix F, there are more detailed discussions of the critical findings and issues of the BRP related to each of the structure types submitted by the Consultants. The Table following this Section summarizes some of these findings and issues.

While many of the specific findings/issues for each structural concept are provided in Appendix F, it is important to highlight several common areas that deserve special focus during both the planning and design phases of this projects. These items include:

- Equipment Air Emissions (with special focus on NOx)
- Long Term Sedimentation Impacts
- Expansion Joint Design
- Runway Transition Zones
- Flexible Pavement Design Details including Thickness of Pavement
- Mitigation Offsets - Beneficial Use of Dredged Material for Wetland Creation
- Short-term and long-term settlement
- Structural stability
- Seismic response
- Costs

Cost estimates and related information was provided in all of the Consultants' Reports. It is very important to note that the Consultants used different approaches to arrive at the estimated costs and that none of these approaches included all of the items that would ultimately be part of the total project costs. An attempt was made by ADEC to adjust all cost submittals to a common cost basis. All of the Consultants' costs were significantly increased. Principal reasons for the increases were due to omissions by the Consultants and, more particularly, the exclusion of adequate or any contractor and owner mark-ups. None of the Consultant total costs should be considered as the basis for the project as they lack significant cost adjustment to address these mark-ups and other items to equitably compare the total cost of one concept to another. The indicated costs, however, do give a relative comparison of one structure system versus another. In order to obtain the best overall performing system from design, environmental and operational perspectives, the final project will probably be a composite of several features of each Consultant's proposal. Once the project has better definition, more realistic costs can be obtained from the next stage of engineering design.

TABLE
STRUCTURE TYPE COMPARISONS

Structure	Advantage	Disadvantage
Fill	• Least cost	• Perceived more sedimentation and shoaling than other concepts
	• No different transition sections	• Seismic damage in localized areas
	• Can hold a constant elevation (+7') throughout	• Maintenance due to continuing settlements
	• Easy to inspect after seismic event	• Air quality during construction
	• Resource availability (labor/material)	
	• Lower life cycle costs	
With rock dike	• Perceived greater perimeter stability	• Larger footprint
	• Lower maintenance cost	
With sheet pile	• Smaller footprint	• Potential for differential settlements • Seismic Risks Increased
Pile	• Improved environmental perception	• Inspection and repair after major seismic event
	• Reduced Seismic Risk	• Resource availability (labor/material)
	• Off site pre-fabrication.	• Expansion Joints. Need to minimize
	• Better initial water circulation	• Transitions to fill sections
		• Noise during construction
		• Lights and drainage more difficult
		• Much higher cost than fill
Steel	• Minimal dredging	• Foreign supply to meet demand
		• Highest runway elevation +23.5'
Cast in place	• Minimal marine support	• More labor intensive than fill concepts
Cast off-site	• Multiple local sources	
Bottom-Founded	• Similar to piles (except for higher seismic risk)	• Seismic uncertainty
	• Overhead clearance	• Differential settlement
	• Diversified construction	• Much higher cost than fill
	• Least NOx emissions	• Reduced pile spacing
		• Inspection and repair after major seismic event

RECOMMENDATIONS FOR ADDITIONAL STUDIES AND TESTING

There are still a number of critical construction and engineering issues that need to be examined in more detail. These are as noted in the following list:

- Earth Fill Structure

  During the design of the earth fill structure, additional studies will be required to determine quality and quantity of fill sources, required soil characteristics for stability, compatibility of the embankments and liquefaction characteristics.

  Proposed borrow areas must be investigated in detail to determine the quality and quantity of materials available at each source, along with the cost and environmental consequences of developing each source. Extensive geotechnical studies will be required to identify location and quantity of materials available for use, as well as overburden materials that need to be removed to develop the site. Laboratory testing programs must be developed to determine the quality of the embankment materials including gradation, compatibility, and resistance to liquefaction. The cost and time required to develop the necessary compaction of each proposed material will significantly affect the cost and schedule of construction and could affect a decision on which sources of materials should be used. Environmental impacts of obtaining materials from the borrow site, transporting them, and placing them must be studied in detail including turbidity, erosion, shoaling, etc.

  A thorough review should be made of the earth fill characteristics and performance of similar projects in the Oakland/San Francisco Bay Area, both during the Loma Prieta seismic event and during the period of time that the fills have been in place. These studies should include the airfields at Oakland International Airport, San Francisco International Airport, and all other commercial and harbor facilities constructed in the area. The type of fill material used, water and Young Bay Mud depths, soil profile and physical characteristics of existing foundation soils, and the method of backfill and compaction should be beneficial data in such a study. Information on fill behavior during construction, as well as long-term settlement and stability character before and after seismic events, should be studied to provide data for design of this project.

An instrumental test fill at the airfield site with wick drains through the muds would assist in several ways. Firstly, to optimize wick spacing, secondly to check wick installation (there are sometimes problems with smearing which greatly reduces their efficiency) and thirdly to assess settlement. About a year should be allowed for such a trial, which means that it should be started as soon as possible.

The constructed test fill should be placed under water and compacted with the same vibro-compaction equipment proposed for use in the development of this project for the purpose of determining the time required to obtain compaction, the effort required to obtain compaction, and the cost of this compaction operation. Detailed analysis should be conducted to determine if the soil compacted in place will be stable and not liquefy under major seismic events.

The above will not provide information on secondary compression. The use of small diameter samples for consolidation testing is notorious for providing misleading consolidation characteristics and consideration should be given to obtaining large diameter samples for long term laboratory consolidation tests.

- Pile Supported Structures (PSS) - Test Pile Program

  A pile installation and test program should be performed at the airport site. The test program should consist of a minimum of three (3) prototype piles to be constructed and driven (installed) as proposed in the final design for the actual runway platform construction. At least one pile should be load tested, both vertically and horizontally. Vertical short term overloads and long term service level loads should be applied to the pile to characterize settlement. One pile should be instrumented with strain gages and tilt meters to measure pile strain and curvature distributions. The pile should be loaded first to Lower Level Earthquake (LLE) demand displacements, and second to Upper Level Earthquake (ULE) demand displacements with three (3) fully reversed cycles of lateral load. Finally the pile should be loaded monotonically to failure, defined by a drop of lateral capacity to 85% of the maximum achieved lateral resistance.

A borehole with continuous sampling will be required at the location of each group of test piles. Consideration should be given to examining the benefits of grouting of the pile shafts/bases as this considerably improves load/settlement characteristics.
Since the seismic safety and performance of the pile supported structure depends on the development and performance of the plastic hinge at the pile top and the integrity of the pile-to-deck connection, a large or full scale proof test of this critical sub-assemblage should be performed under a fully reversed cyclic loading protocol. This test will show the seismic performance and damage patterns at the defined design levels, LLE and ULE, and will provide information on the actual ductility capacity of the specimen. Full scale proof tests are pretty standard for Caltrans on new or important design details.

- Bottom-Founded Structures

  Two segments of the final design for the bottom-founded structure should be manufactured and installed on the soft bay mud to demonstrate installation procedures and settlement response. The BFS test section should be loaded with overburden or deep soil anchors both symmetrically and eccentrically to the joint between segments to simulate uniform and non-uniform settlement conditions. The test section should have the full flexible runway surface, and the segment joint region should be instrumented to measure runway discontinuities.

  A large or full scale laboratory proof test of the plastic hinge region in the BFS columns should be performed to characterize the seismic response. This proof test should be conducted as outlined for the PSS concept proof test.

A detailed preliminary design study on the feasibility of the BFS concept should be conducted first to assess the BFS impact on environmental conditions, seismic response and constructability.

CONCLUSIONS

This investigation and presentation process has been of significant value in identifying the benefits and drawbacks of different construction and engineering methods for the proposed runway structure types and configurations, and particular areas for additional analysis. It has allowed the BRP to develop "Best Practices" for the proposed project in the form of four (4) guiding principles and associated design issues. The BRP also feels that the final selection likely will turn out to be a composite and expansion, or improvement, upon several of the structural concepts that were investigated and discussed. This would put less strain on the specialized resources in the Bay Area, allow concurrent construction activities, thus, improving the overall construction schedule, and collectively reduce the seismic risk of the entire facility. The following conclusions were reached by the BRP:

- All three (3) structural concepts (EFS, PSS, and BFS) can be used with reasonable assurance to perform satisfactorily.
- The earth fill structure is the least costly, stable, easy to maintain and inspect and, therefore, if environmental concerns and a possible longer construction schedule are not overriding, the earth fill structure is the most appropriate solution.
- If environmental factors are overriding, the pile supported and bottom-founded structures can be used where a total new runway platform is being built. Extensions to existing runway platforms should be a earth fill structures.
- The bottom-founded structure presently is not well-defined and hence has questions about its reliability from a structural standpoint compared to a pile

supported structure. It should only be used for a complete structure, if permitting and construction concerns do not allow an earth fill or pile structure to be used.

Findings relative to each runway platform configurations are:

Configuration A3

All transitions from existing to new construction would be earth fill structures as well as the extensions to 28L, 19L and 19R. Runway Platform 10L/28R could also be an earth fill structure if there were no overriding environmental issues and if suitable fill is available. If an all-fill approach is not environmentally acceptable, the Runway Platform 10L-28R should be a pile-supported structure.

Configuration F2

The total project would be earth fill structures if there are no overriding environmental issues, and if suitable fill material is available. If an all-fill approach is not environmentally acceptable, Runway Platform 10L/28R would be piles with the possibility that Runway Platform 1L/19R could also be a bottom-founded structure. The bottom-founded structure could be used in lieu of the pile supported structure if the technical and environmental concerns about its use can be resolved. Runway Platform 1R/19L and all extensions should be fill.

Configuration BX-Refined

The total project would be fill if there were no overriding environmental issues and if suitable fill is available. If not, Runway Platform 10L/28R would be a pile supported structure, but sloped from elevation 7' – 0" at the West end to 17.5' at the East end. All other runway platforms and extensions would be earth fill structures.

It is not the function of the BRP to make a selection of the runway configurations or the type of structures to be used. The BRP is sensitive that the ultimate decision will not, and should not, be based on engineering and construction considerations alone. In particular, the Commission will be examining closely the environmental and financial aspects of the project.

On behalf of the Blue Ribbon Panel members,

John H. Azeveda
Reinard W. Brandley
George C. Hoff
Owen Miyamoto
Graham W. Plant
Frieder Seible
Alfred A. Yee

Respectfully submitted,

George C. Hoff, D.Eng., P.E.
Chairman, Blue Ribbon Panel

APPENDIX A

BLUE RIBBON PANEL RESUMES

John H. Azeveda

Mr. Azeveda retired from the U.S. Army Corps of Engineers (COE) San Francisco District, after a combined 20-year career as Chief of Construction Management Branch and Chief of the Operations Branch. This has provided him with extensive knowledge of the San Francisco Bay and estuary navigational and environmental issues. He also had responsibility for many flood control and facility maintenance projects. During his career, he was responsible for technical support of navigation by marine vessels in San Francisco Bay, including support and oversight of the District's dredging and construction projects.. In this capacity, he was responsible for the navigation and hydrographic survey sections. He was also responsible for assuring compliance with environmental review guidelines for operations. He was tasked specifically with the day-to-day monitoring of San Francisco Bay and coastal harbor navigation channel condition surveys and coastal navigation structure conditions to support navigation requirements, including necessary dredging. As Branch Chief, he was directly responsible for the coordination of many navigational and environmental issues with the U.S. Coast Guard, EPA, National Marine Fisheries Services, California Fish and Game, BCDC, Bar Pilots, Harbor Masters and Regional Water Quality Control Board.

Mr. Azeveda received a B.S. in Civil Engineering from San Francisco State University and is member of the Western Dredging Association. During his COE career, he was extensively involved in the administration of a variety of general construction, navigation, coastal and flood control projects, including contract negotiations, claim resolution and litigation proceedings. He also was frequently called upon to provide construction operation reviews, guidance, and management of critical projects, including the re-building of levees after the Loma Prieta earthquake and the Oakland Harbor 42 feet deepening project.

Reinard W. Brandley

Mr. Brandley established the Sacramento based engineering firm of Reinard W. Brandley, Consulting Airport Engineer, in 1953 and serves as its Principal and Chief Engineer. He has extensive design experience in both asphaltic and Portland cement concrete airfield pavements. Mr. Brandley is considered one of the leading developers of the fatigue analysis method of pavement design applied in the United States. This method utilizes the layered elastic theory and is based on failure criteria limits associated with subgrade deflection/strain under critical aircraft loading conditions. The theory of fatigue analysis has a 42 year successful application record for design and evaluation of airfield pavements. Mr. Brandley's qualifications and experience as a geotechnical engineer and application of the layered elastic theory have led to an ability to focus on the long life, low maintenance designs, through the prudent use of local materials.

Brandley Engineering is a full-service consulting airport engineering firm under the direction of Reinard W. Brandley specializing in airport planning; pavement evaluation and design; airport engineering design; and construction project management, including testing and inspection. Airport planning and design services have been continuous since 1953. The firm has performed services for over 150 airports throughout the United States including Sacramento International Airport, San Diego International Airport, Seattle-Tacoma International Airport, Honolulu International Airport, Standiford Field in Louisville, Kentucky, Nashville International Airport, and United Parcel Service hubs in Louisville and Ontario.

Mr. Brandley has a B.S. and M.S. in Civil Engineering from the University of Alberta and a M.S. in Civil Engineering from Harvard University. He is a Registered Civil Engineer in California and 7 other States and a Registered Geotechnical Engineer in California.

George C. Hoff

Dr. Hoff currently is the Principal in Hoff Consulting LLC in Clinton, Mississippi. From 1982 to 1999, Dr. Hoff served as a senior structural engineer for Mobil Oil in the specialty disciplines of offshore structures, oil and gas platform structures, and coastal and harbor structures. This work included research and development, structural analysis, construction and repair. Major projects undertaken by Mobil with Dr. Hoff's participation include: Northern Taiwan Liquefied Natural Gas Terminal; Northern

Adriatic Sea Liquefied Natural Gas Terminal; Barge-Like Floating Structures for Liquefied Natural Gas Production in Indonesia, West Africa and Australia; and concrete offshore oil platforms in the North Sea, Australia, Indonesia, the Gulf of Mexico, and Canada. In Canada, the Hibernia Platform (Newfoundland, Canada) was the largest offshore structure in North America. For the Hibernia project, Dr. Hoff was responsible for concept development, bid preparation and evaluation, contractor selection, contract negotiations, and technical assistance to engineering, construction and QA/QC. Prior to his association with Mobil, he served 20-years on the staff of the U.S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi leaving there as Chief of the Concrete Analysis and Materials Division. In that capacity, he dealt with military airfield construction and repair problems.

Dr. Hoff received a B.S. in Civil Engineering and a M.S. in Theoretical and Applied Mechanics from the University of Illinois; a Doctor of Engineering (D.Eng.) from Texas A&M University. He is a Past-President of the American Concrete Institute and a Registered Professional Engineer in Mississippi. He has authored or co-authored over 150 technical papers, reports, and 3 books on construction and construction materials.

Owen Miyamoto

Mr. Miyamoto retired in 1996 after nearly 44-years of government service with the State of Hawaii. He has extensive experience in all aspects of airport design, operations, maintenance and administration. Mr. Miyamoto currently serves as a lecturer in the Aeronautics Maintenance Technology Program at the Honolulu Community College. During his tenure as Airport Administrator, the State of Hawaii embarked on a major capital improvement program leading to the construction of the Reef Runway, Runway 8R/26L, at Honolulu International Airport. This runway, which was completed in 1977 and became fully operational in 1978, is offshore and constructed entirely on reclaimed land. Pre-design activity required an extensive environmental monitoring and baseline data-gathering program. Subsequent to completion of the runway, Mr. Miyamoto directed a comprehensive post construction environmental impact assessment to measure impact on surrounding ocean hydrology and ecology.

Mr. Miyamoto received a B.S. in Civil Engineering from the University of Hawaii and a M.S. in Civil Engineering from the University of Illinois. He is a Registered Professional Engineer in the State of Hawaii in the Civil and Hydraulic Branches.

Graham W. Plant

For over 7 years, Dr. Plant was engaged in the development of the new Hong Kong International Airport from inception to completion. From April 1995 to May 1999, he served as the Head of Engineering for the Airport Authority. In this role, he was responsible for all engineering disciplines as well as architectural, environmental and other related activities for the new airport. Dr. Plant was the Engineer under the Contract for the 3000-acre site reclamation. Prior to joining the Hong Kong Airport Authority, Dr. Plant was engaged from 1973 to 1992, in the design and construction of civil infrastructure and building projects principally in the United Kingdom and Southern Africa while serving as a Director of Ove Arup and Partners. Much of the work in Southern Africa was devoted to site infrastructure, foundations for commercial buildings and civil engineering in the mining and power generation industries. These involved a wide range of pile types and ground improvement measures.

Dr. Plant received a B.Eng. and Ph.D from Sheffield University. He is a Chartered Engineer, a Registered Professional Engineer in South Africa and a Fellow of the Institution of Civil Engineers and the Hong Kong Institution of Engineers, a Member of the American Society of Civil Engineers and the South African Institution of Civil Engineering. He is the author of many articles and technical papers with particular emphasis on practical solutions to complex engineering issues, including a book on the design, construction and performance of the site preparation of the Hong Kong International Airport. Dr. Plant now acts as an independent consultant in the broad areas of Project and Peer Review, Value Engineering and Project Management.

Frieder Seible

Dr. Seible is Professor and Chairman of the Department of Structural Engineering at the University of California, San Diego, where he also founded and directs the Charles Lee Powell Structural Research Laboratories, the Nation's leading large scale research and testing facility for structural systems under simulated seismic input. Prior to his 18 year tenure at UCSD, Dr. Seible was a design Engineer with Philipp Holzmann in Germany, designing bridges in three different continents. Dr. Seible serves on the Caltrans Seismic Advisory Board and has participated in and chaired numerous Seismic Safety Peer Review Panels for Caltrans on all major California bridge projects (retrofit and new design). Following the 89 Loma Prieta and the 94 Northridge earthquakes, Dr. Seible chaired the Caltrans Review Panels for the assessment and reconstruction of all damaged and collapsed bridge structures. Currently he is involved I the Seismic Safety Review for the new San Francisco Oakland Bay Bridge design.

At the international level, Dr. Seible is currently conducting seismic safety peer reviews for two of the world's largest bridge projects, namely the Rion – Antirion Bridge across the Strait of Corinth in Greece and the Canal de Chacoa Bridge in Chile.

Most of the seismic retrofit technology used by Caltrans in their $ 6 billion + bridge seismic retrofit program has been developed in the Powell Structural Research Laboratories at UCSD under Dr. Seible's directorship.

Dr. Seible received his Ph.D. degree in Civil Engineering from the University of California, Berkeley, and has published over 450 books, papers and technical reports. He is a member of the National Academy of Engineering and was named as one of the top 125 people contributing most to the construction industry over the last 125 years by ENR.

Alfred A. Yee

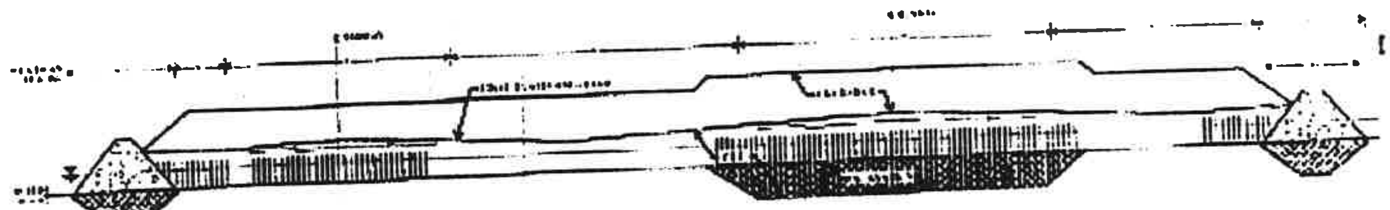
Mr. Yee is President of the Honolulu based engineering applications firm of Applied Technology Corporation. His accomplishments in the field of concrete technology for land and marine structures are extensive. In 1964, Mr. Yee designed and supervised the construction of the world's first pretensioned, prestressed, concrete ocean-going barge. A total of 19 barges were constructed to transport ammunition, food and fuel from the Philippines to the U.S. Military forces in Viet Nam. Mr. Yee developed and patented a novel concept for marine structures. This concept utilizes reinforced concrete in the form of a honeycomb cellular core in composite action with prestressed top and bottom slabs and side walls and can produce a structure with maximum strength and rigidity with least amount of construction material. The initial structure, ROFOMEX 1, was constructed in Singapore and towed over 10,000 miles across the Pacific Ocean to Baja California to support a large phosphate processing plant at Santa Domingo.

His honeycomb system was also employed successfully in the construction of the Gloma Beaufort Sea I, otherwise known as the Concrete Island Drilling System (C.I.D.S), a major offshore drilling platform operating in Prudhoe Bay, Alaska.

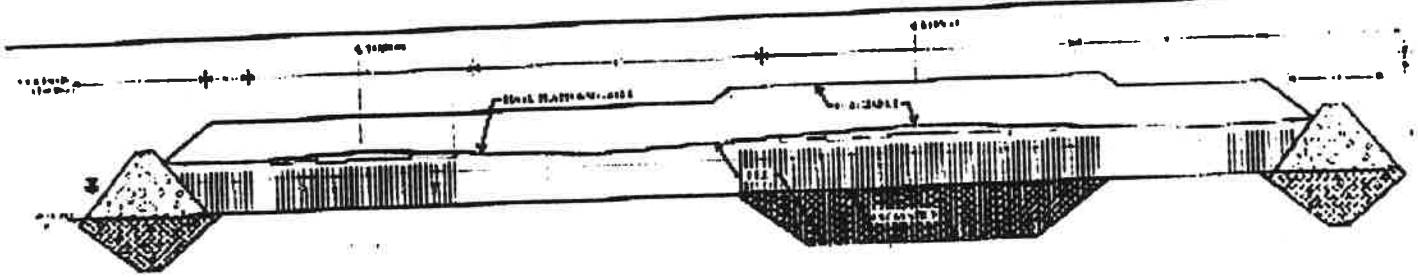
Mr. Yee has a B.S. in Civil Engineering from Rose-Hulman Institute of Technology and an M.S. in Structural Engineering from Yale University. He is a Registered Engineer in Hawaii and 5 other States of U.S. Territories, holds over 12 U.S. patents in land and marine based structures, and in 1976, was elected to the prestigious National Academy of Engineering and awarded an Honorary Doctor of Engineering Degree by Rose Hulman Institute of Technology. In 1997, he was awarded the Medal of Honor by the Precast/Prestressed Concrete Institute for his innovative designs in this field.

APPENDIX C

TYPICAL STRUCTURAL CONCEPTS

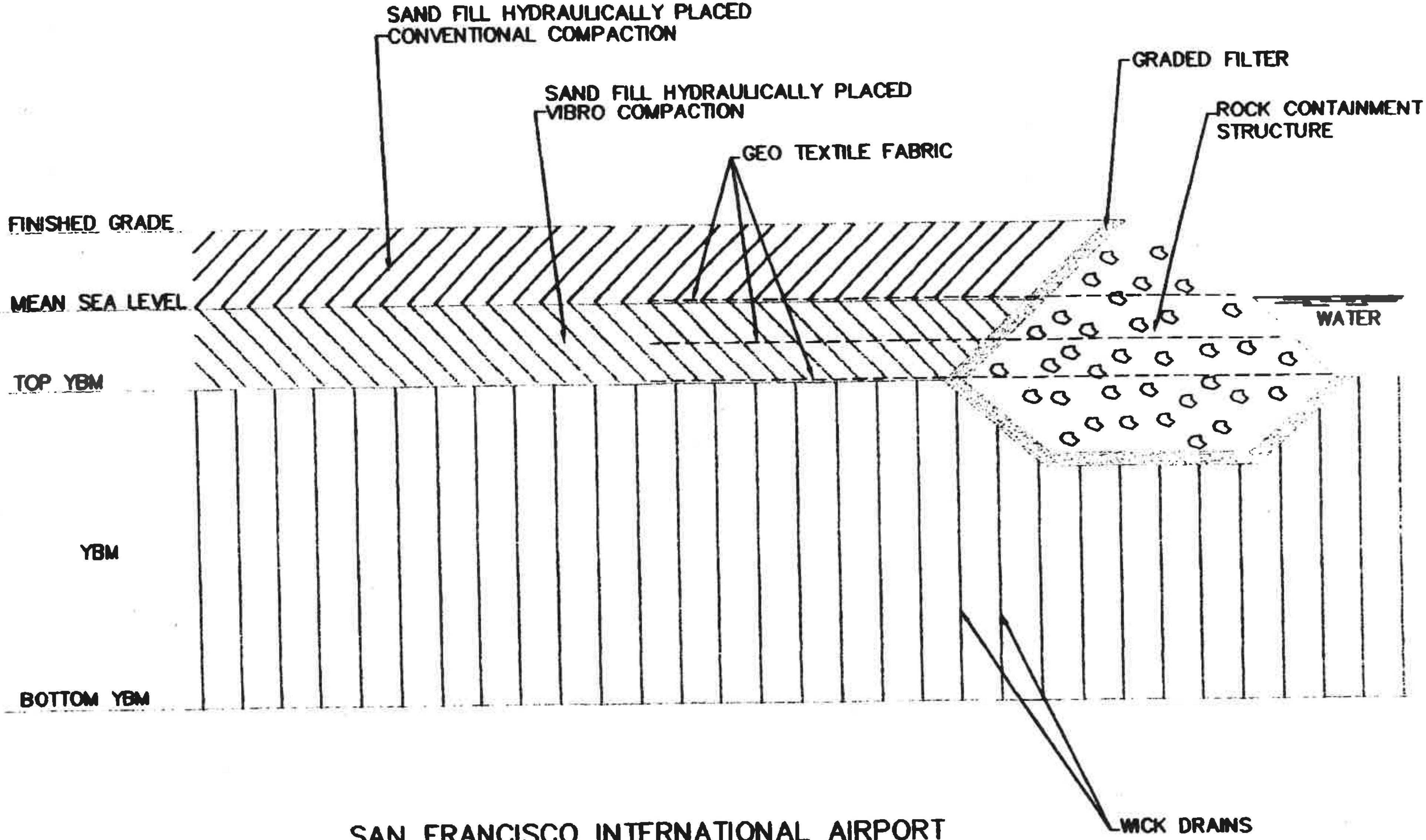


Representative Section with Thinner Young Bay Mud in Shallower Water

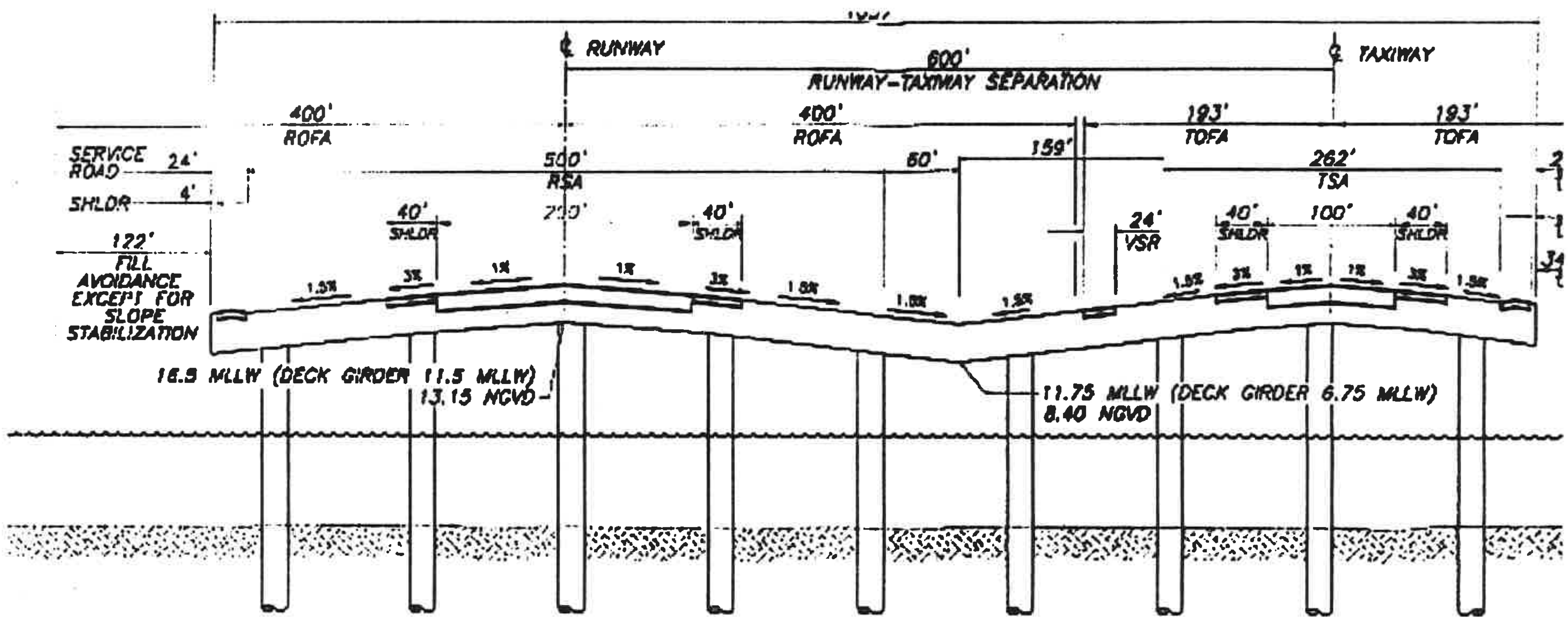


Representative Section with Thicker Young Bay Mud in Deeper Water

OPTION A:
- Overexcavate 1/3 under dike and runway only (deepen at tie-in to existing airfield)
- 20' surcharge over runway, 15' over remainder of platform.
- Drainage spacing to achieve results with a surcharge duration of 3 months.
- Stone columns for "critical" runway with local fill

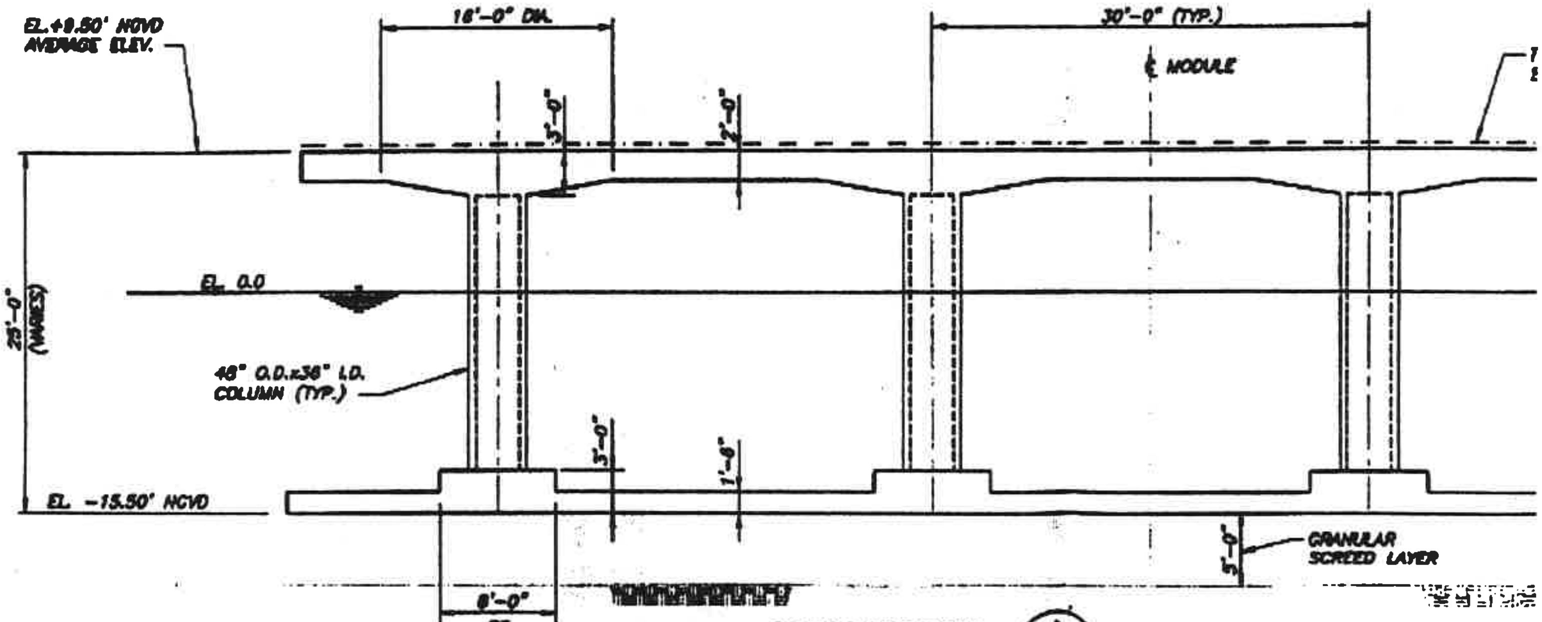


SAN FRANCISCO INTERNATIONAL AIRPORT
EARTH FILL STRUCTURE CONCEPT
TYPICAL IDEALIZED HALF SECTION



PILE SUPPORTED STRUCTURE SECTION

NTS



CROSS SECTION
1"=10'-0"
A
2.11

BOTTOM FOUNDED CONCEPT - MODULE PLAN AND ELEV.

APPENDIX D

CONCEPT STUDY PROPOSAL REQUIREMENTS

Runway Reconfiguration Program

Offshore Runway Construction Concepts

Contract No. 7042.23

EXHIBIT A

SCOPE OF WORK

DATE: APRIL 7, 2000

City and County of San Francisco

San Francisco International Airport

Airfield Development Bureau

Exhibit A – Attachments

1. Geometry of Proposed Runways – Alternative BX Refined, ***Revised March 31, 2000***
2. Geometry of Proposed Runways – Alternative F2, ***Revised March 31, 2000***
3. Geometry of Proposed Runways – Alternative A3, ***Revised March 31, 2000***
4. Aircraft Fleet Mix and Landing Gear Layout, ***Revised April 7, 2000***
5. Airfield Clearance and Obstacle Free Zone Requirements
6. Life Cycle Cost Estimate Format
7. Seismic Loading ***(will be provided by April 24, 2000)***
8. Settlement/Displacement Criteria, ***Revised April 7, 2000***
9. Preliminary Site Characterization Report, binder name list, consists of a total of ten (10) binders, prepared by Airfield Development Engineering Consultants Joint Venture.
10. Description of Navaids, Drainage Utilities and Lighting for Runway Reconfiguration Program.
11. Layout Drawing of Navaids, Drainage, Lighting and Utilities– Alternative A3
12. Layout Drawing of Navaids, Drainage, Lighting and Utilities– Alternative BX Refined
13. Layout Drawing of Navaids, Drainage, Lighting and Utilities– Alternative F2
14. Excerpt of FAA Advisory Circular 150/5300-13, dated 9/29/89 – Chapter 5, Surface Gradient and line of sight, Chapter 6, site requirements for NAVAID and ATC Facilities, and Chapter 7, Runway and Taxiway Bridges.
15. Maintenance Intervals and Costs

I. Introduction

A. Airport's goals

San Francisco International Airport is experiencing unacceptable flight delays and aircraft noise levels which cause considerable community concern. SFO is anxious to reduce these concerns as quickly as possible. At least five alternatives are being examined for the EIR/EIS:

- Do nothing
- No Build: use of technology, operational enhancements and systems management measures to increase efficiency of existing infrastructure.
- Alternative A3
- Alternative BX Refined
- Alternative F2

SFO has set the following objectives:

- Reduce flight delays
- Reduce human exposure to aircraft noise
- Accommodate new large aircraft
- Produce net environmental gains for the Bay

SFO is seeking a broad range of feasible design and construction options for reconfigured offshore runways. Through the RFQ/RFP process, the engineering and construction community was encouraged to form teams based on creativity, experience and talent, to develop ideas and concepts which can be constructed as quickly as possible, have a long design life, have acceptable costs, and minimize environmental effects.

B. Process

Based on the responses on the Request for Proposals and interviews, several teams have been selected to be awarded a contract to develop the concept, prepare plans and details, perform calculations, select materials, provide logistics, prepare a construction schedule, and prepare a life cycle cost analysis.

Each team will be compensated $250,000. The teams will have 3 months to finalize the concepts and submit the supporting material. SFO, supported by the Blue Ribbon Panel, will review the concepts, using criteria which include construction schedule, design life, constructability, minimization of environmental effects, life cycle costs, feasibility of construction concept, minimization of environmental effects, design life, construction cost, life cycle costs, and conformance to the Airport's engineering requirements as stated in this Scope of Work.

SFO plans to select the concept or combination of concepts that best meets and or best balances the established criteria. SFO reserves the right to select or not to select any of the proposed concepts when it decides on a method of construction for the offshore runways. SFO intends to issue a separate RFP for final design based on selected concept(s). SFO will own the information in the submitted concept drawings, reports, schedules and estimates.

C. Requirements

The following requirements will serve as a basis of comparison for the design and construction concepts:

1. Aircraft Loading: See Attachment 4.
2. Impact Factor (for structures): 1.20 times the maximum aircraft takeoff weight.
3. Seismic loading: See Attachment 7, ***Revision to be issued April 17, 2000.***
4. Design Life: 100 years with at least 30 years between major maintenance (reconstruction) activity.
5. Settlement/Displacement Criteria: See Attachment 8, ***Revised March 31, 2000.***
6. Airfield Clearance Requirements: See Attachment 5.
7. Size and Location: The concepts must conform to the dimensions and locations shown in Attachments 1, 2, and 3, ***Revised March 31, 2000***. This is necessary to meet our airspace and aircraft taxi time requirements.
8. Elevation: The elevation of the existing airfield is approximately +11 feet, NGVD datum at the east end of runways 28L and 28R and approximately +7 feet, NGVD datum at the north end of runways 19L and 19R. The new runways may be at the same or higher elevation. Transitions between the existing and new runways and taxiways must not exceed 1½ percent grade and a change in gradient of 3 percent longitudinally. The minimum length of vertical curve is 100 feet per each 1 percent of change; and the minimum distance between points of intersection of vertical curves is 100 feet times the sum of the grade changes associated with the two vertical curves. Transverse grades of the runway shall be between 1 and 1½ percent. For clarification, see Attachment 14.
9. Not used.
10. Limit construction duration to five (*5*) years maximum for Alternatives F2 and BX Refined. Limit construction duration to four (*4*) years maximum for Alternative A3.
11. Should hydraulic or sedimentation information be included, it must be developed using RMA2 or MIKE21 software.
12. Statement of Clarification - All language presented in the RFQ and RFP as amended for the Runway Reconfiguration Project, Contract No. 7042.2, should be carried forth unless expressly noted herein.

Provide a discussion of the adaptability of the proposed concept to more stringent requirements than those mentioned in the aforementioned items.

Any deviation from these requirements may result in the disqualification of the concept. However, provided that one alternative follows the above criteria, a second alternative may be submitted which varies from the requirements in one or two parameters. The reasoning for deviation needs to be clearly stated.

D. Environmental Requirements for Construction Activity:

1. Emit less than 100 tons per year of NOx from all construction equipment and employee vehicles.
2. Emit less than 100 tons per year of particulates (PM10) from all construction equipment and employee vehicles.
3. Emit less than 100 tons per year of CO from all construction equipment and employee vehicles.
4. Emit less than 100 tons per year of VOCs from all construction equipment and employee vehicles.
5. Minimization of Environmental Impacts to San Francisco Bay:

a. Alternatives which minimize fill and structure (especially earth fill) will receive more favorable consideration (Note that due to ***airfield operational*** restrictions, some earth fill will be required).
b. Alternatives which minimize water quality concerns during and after construction will receive more favorable consideration.
c. Alternatives which minimize harm to aquatic life during and after construction will receive more favorable consideration.
d. Alternatives which minimize shoaling and associated maintenance will receive more favorable consideration.

II. Description of the Scope of Work

The description of the Scope of Work is to be used as a general guide and is not intended to be a complete list of all work necessary to complete the project.

Following are minimum work tasks and deliverables necessary to develop Offshore Runway Construction Concepts.

A. Concept Drawings

Provide sufficient plans, sections and details with materials and dimensional information to clearly explain the concept. Provide sufficient calculations to demonstrate adequacy of concept to meet the requirements.

All concepts shall be based on the designated layouts "A3, BX Refined, and F2". Consultants may qualify their design but need to include the reasoning behind any exception.

B. Environmental and Maintenance Issues

Provide information necessary for other consultants to assess environmental impacts to environmental resources, such as air quality, water quality, hydraulics, shoaling and scour, noise, recreation, marine flora and fauna, for example, provide the number of hours each piece of equipment will run each day per schedule month and the type of engines on that equipment. Provide information about the materials and finish of each element touching the water, any mitigation measures to be used such as silt curtains of geotextiles, etc. All fabrication areas, work areas, staging areas, and routing of equipment shall be shown, along with any needed construction access channels to be dredged. **Show any landside access needed.**

Sufficient detail shall be shown for accurate environmental studies by other consultants in the following areas:

1. Dredging and filling – provide area and volume of dredging required, provide area and volume of fill required, provide area of structure required.
2. Water quality
3. Biology
4. Air quality
5. Construction noise including pre-casting yards, transportation, borrow and disposal.

Describe the procedures for annual maintenance: equipment, access, etc.

C. Basic Material Specifications

Enough specification data should be attached to clearly indicate material performance characteristics, erosion and corrosion protection or any unique installation requirements.

D. Description of Constructability Analysis, Material Handling and Logistics:

1. For each activity on the schedule, provide a description with specifics of the methodology, equipment, staging areas, access for workers and equipment, and other logistics.
2. Provide a minimum of twelve sequencing plans for the various phases of construction.
3. Estimate labor type and level of resources required each month throughout construction.

E. Schedule

1. Design Schedule Format: Weekly units, at least fifteen tasks.
2. Provide construction schedule indicating the basic construction operations on each runway segment with special indication of construction activities and duration inside obstacle free zones.
3. Construction Schedule Format: Monthly units, Primavera software, at least 80 tasks, Level 3 schedule, with Primavera Logic Report.
4. Construction Cash Flow Schedule, by month.

F. Estimate

Use HCSS Estimating Software (or, alternatively, use R.S. Means, Saylor or Equivalent forms) for all the estimates below:

1. Construction Estimate: Show costs for each separate crew and trade. Use Bay Area prevailing labor wages, equipment, material pricing. Include quantity takeoff, pricing, general conditions assumptions and allowance assumptions. Include any cost premiums for scarce labor resources.
2. Annual Maintenance Cost Estimate: (includes asphalt overlays, crack repair, etc.): due to expected differential settlement and FAA requirements to maintain grades as described in I.C.8 and **Attachment 14** regular maintenance is expected and costs must be included; use Bay Area prevailing wages, equipment and material pricing.
3. Annual Inspection Estimate: Use prevailing wages and equipment prices; provide estimate of time per linear foot of Runway. Include confined space mobilization where appropriate.
4. Annual Operating Cost Estimate: Use prevailing wages and equipment prices; show assumptions for electric power, compressed air, etc. necessary to operate the structure itself (exclude airfield lighting and navigational aids).
5. Major Maintenance Cost & Interval: Major maintenance involves partial reconstruction; use Bay Area prevailing wages, equipment and material pricing.
6. Life Cycle Cost Estimate Format: see attachment 6; base on 7% Capital Interest Rate.

G. Deliverables

1. Monthly reports: Initial report shall be submitted at end of first month, together with a reporting meeting. Intermediate report shall be submitted at end of second month. The final report shall be submitted at end of the third month.
2. All submittals shall include twenty (20) hard copies plus one electronic copy. The drawings shall be in AutoCAD 14 format.

3. Presentation: A meeting for each Contractor will be scheduled in August, 2000 for their presentation of the final detail concept to the Blue Ribbon Panel and the Airport staff.

- End of Scope of Work -

Runway Reconfiguration Program

Offshore Runway Construction Concepts

Contract No. 7042.23

HRC and Campaign Contribution Forms

DATE: APRIL 7, 2000

City and County of San Francisco

San Francisco International Airport

Airfield Development Bureau

Exhibit B – HRC and Campaign Contribution Forms

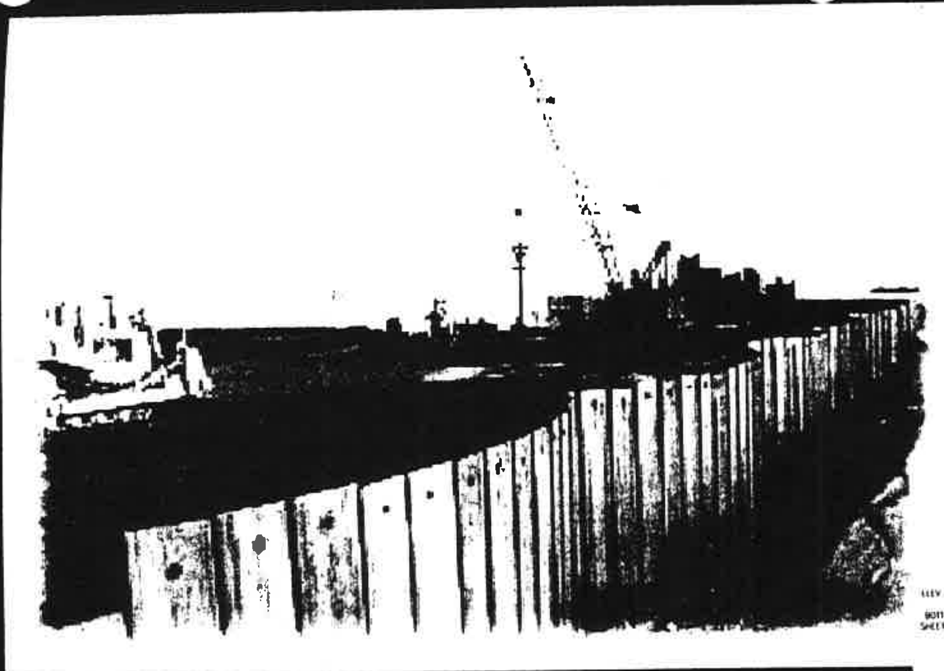
- Attachment 2, Human Rights Commission (HRC) Requirements
- Notice to Prospective Airport Contractors Regarding Prohibited Campaign Contributions to Elected City Officers and Candidates for City Office with Authority to Approve Proposed Contract (Three pages: Issued 8/11/99)

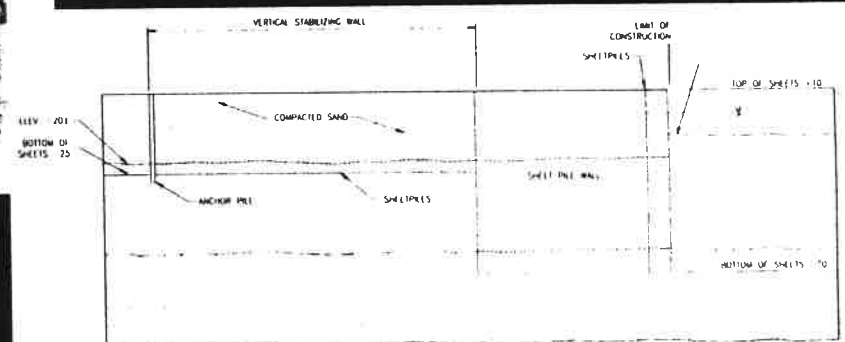
APPENDIX E

STUDY PROPOSAL CONCEPTS

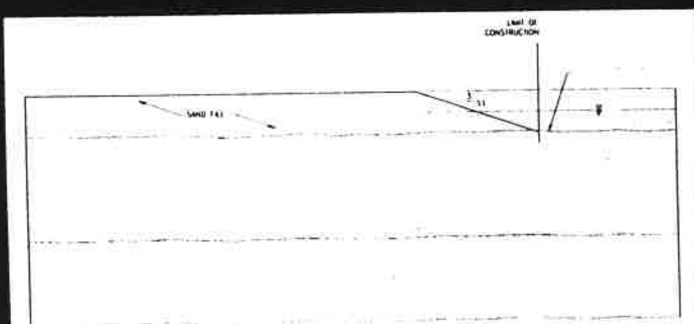
SFO

San Francisco International Airport

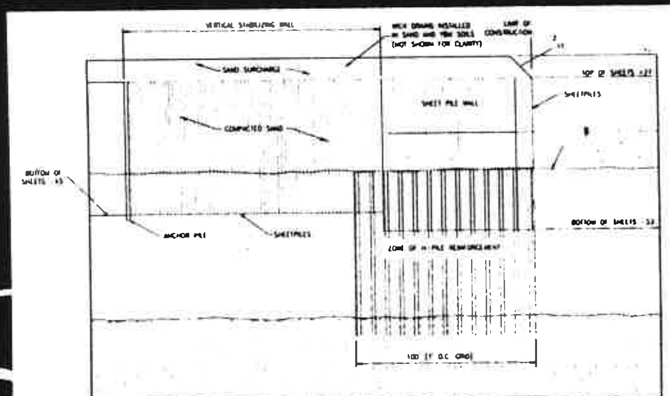




FINISHED CONFIGURATION - AREA WITH THINNER YOUNG BAY MUD LAYER



UNCONFINED FILL PLACEMENT

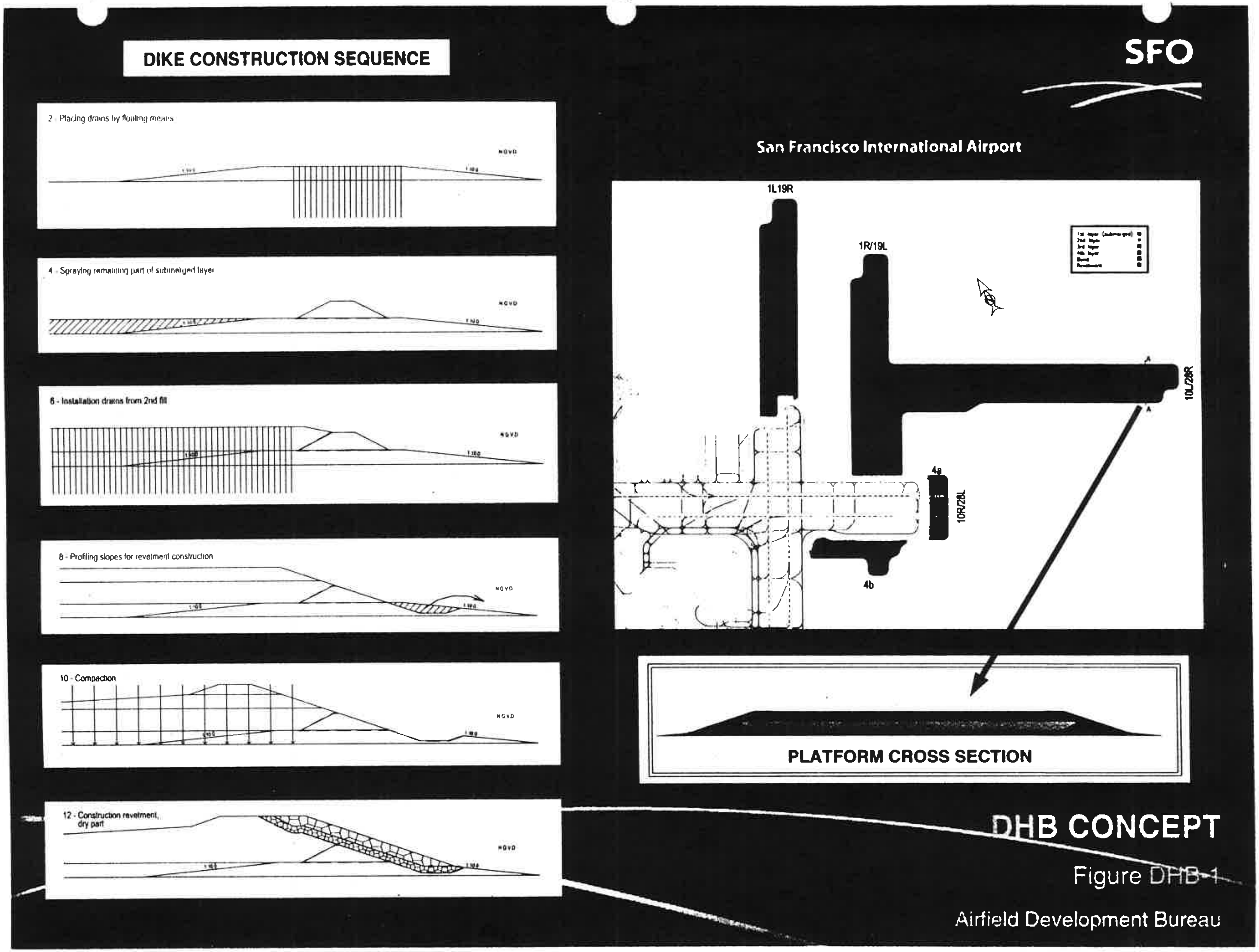


SURCHARGE IN AREA WITH THICK YOUNG BAY MUD LAYER AND H-PILE REINFORCEMENT

PN&D CONCEPT

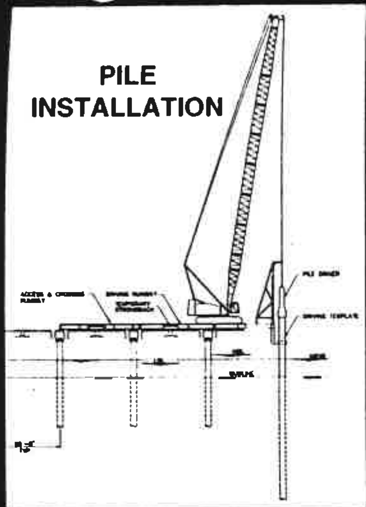
Figure PN&D-1

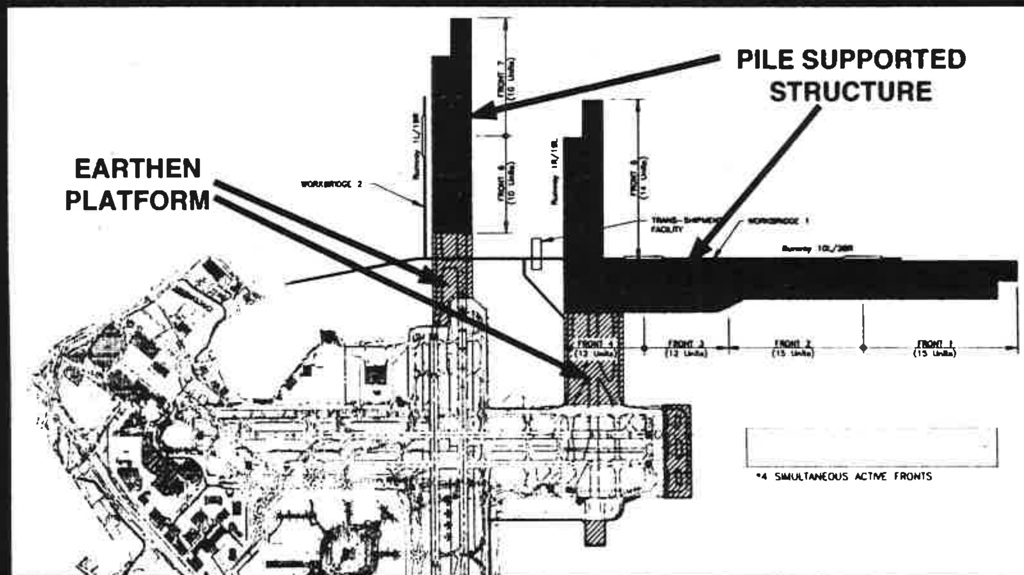
Airfield Development Bureau

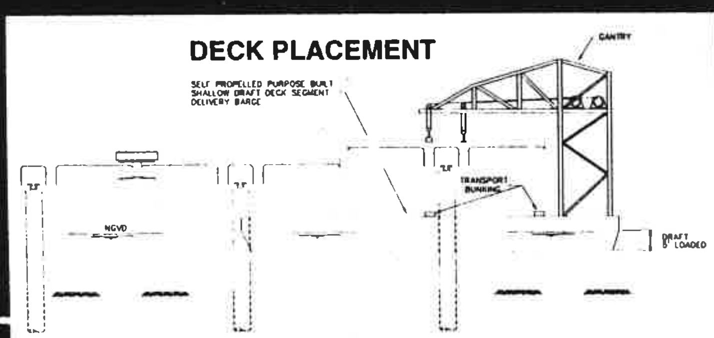

SFO
DIKE CONSTRUCTION SEQUENCE
2 - Placing drains by floating means
NGVD
4 - Spraying remaining part of submerged layer
NGVD
6 - Installation drains from 2nd fill
NGVD
8 - Profiling slopes for revetment construction
NGVD
10 - Compaction
NGVD
12 - Construction revetment, dry part
NGVD
San Francisco International Airport
1L19R
1R/19L
10L/28R
10R/28L
4a
4b
A
PLATFORM CROSS SECTION
DHB CONCEPT
Figure DHB-1
Airfield Development Bureau

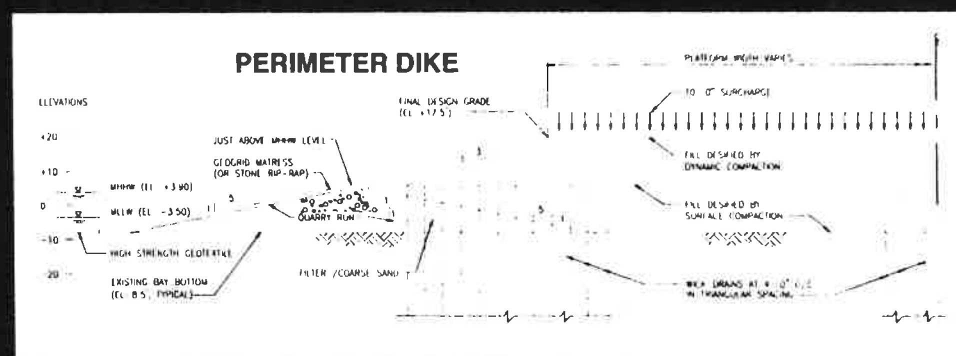
SFO

San Francisco International Airport





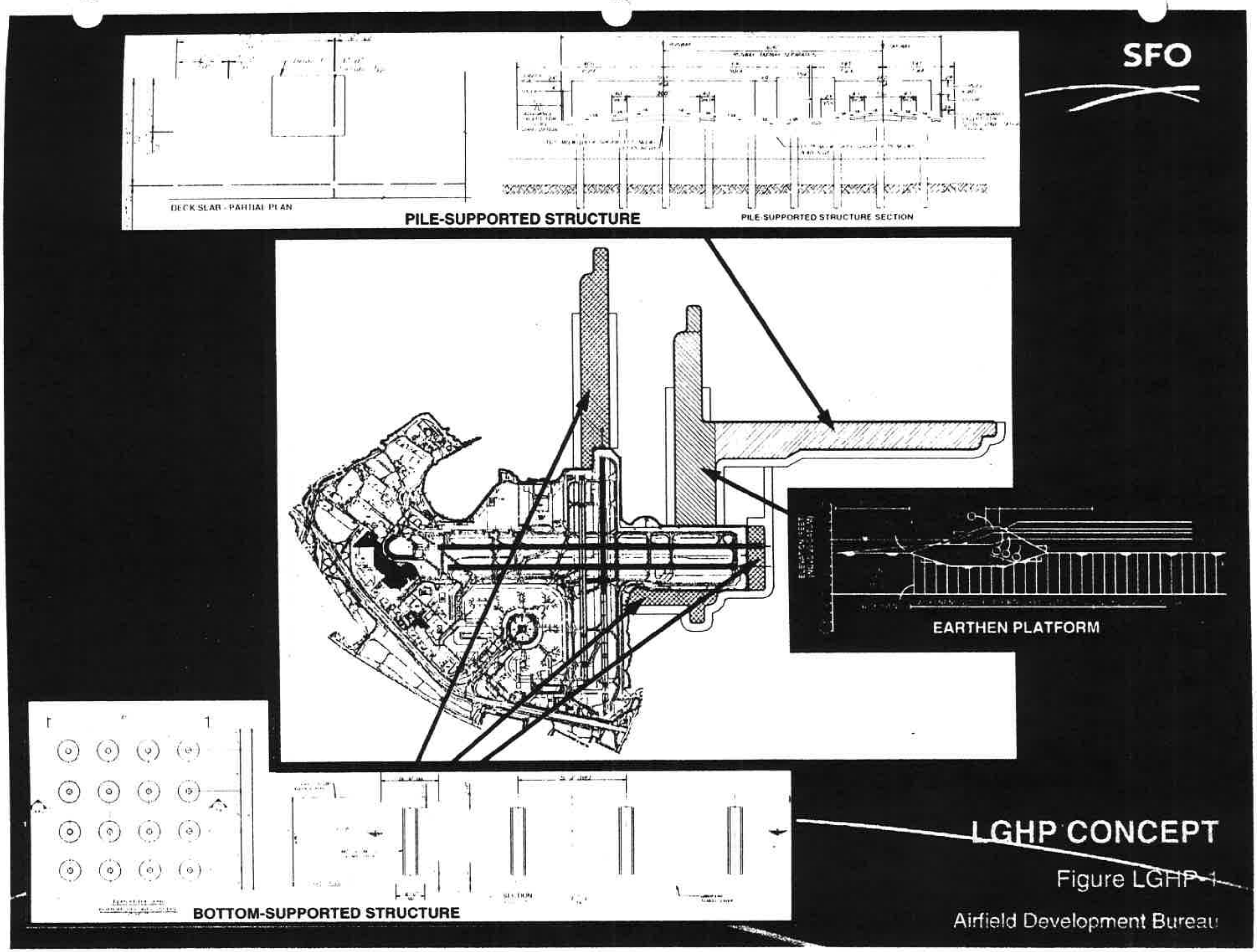




PB CONCEPT

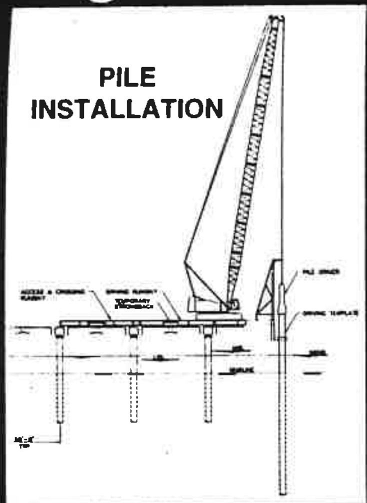
Figure PB-1

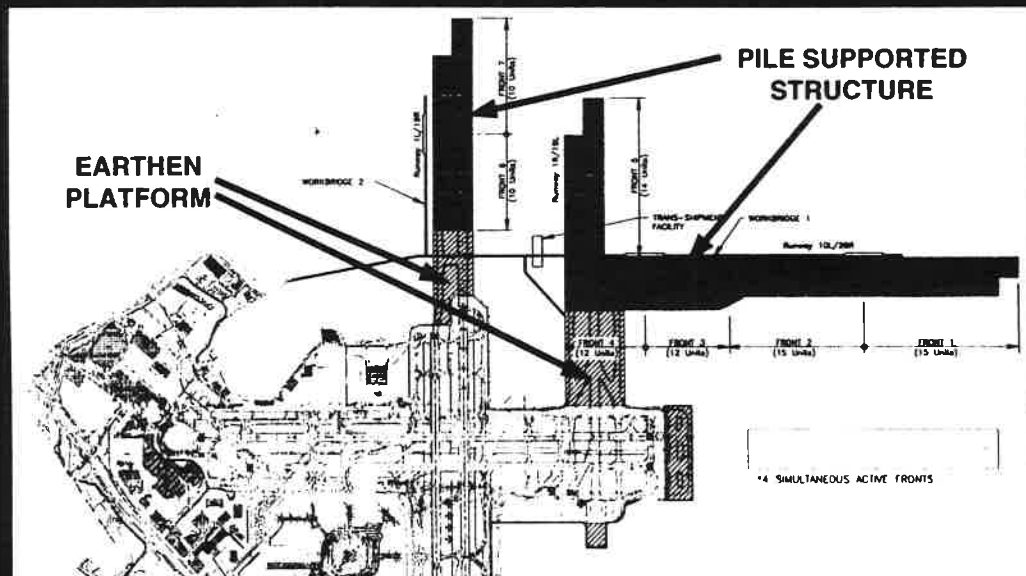
Airfield Development Bureau

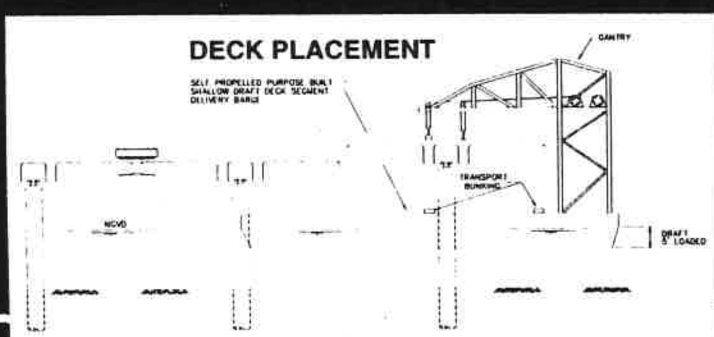

SFO
DECK SLAB - PARTIAL PLAN
PILE-SUPPORTED STRUCTURE
PILE SUPPORTED STRUCTURE SECTION
EARTHEN PLATFORM
BOTTOM-SUPPORTED STRUCTURE
SECTION
LGHP CONCEPT
Figure LGHP-1
Airfield Development Bureau

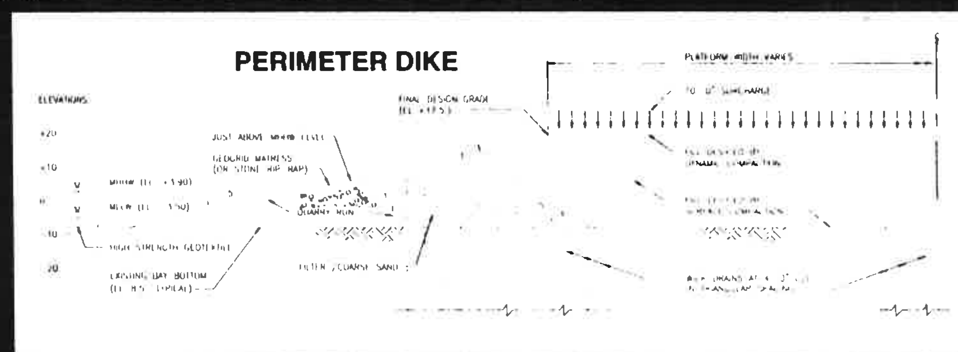
SFO

San Francisco International Airport









PB CONCEPT

Figure PB-1

Airfield Development Bureau

APPENDIX F

STRUCTURE CONCEPT COMMENTS AND DESIGN ISSUES

EARTH FILL STRUCTURES

PILE SUPPORTED STRUCTURES

BOTTOM-FOUNDED STRUCTURES

EARTH FILL STRUCTURES (EFS)

All current runway structures at SFO are fill structures, and they are all at the same elevation. From an airport operations point-of-view, any airport/runway extension or expansion using any earth fill structure would eliminate the need for costly transition structures. Also, fill structures in general seem to provide by far the most cost effective solution.

For fill structures, the most cost and construction time effective fill structure is a dredged fill solution. The critical design considerations for a dredged fill structure include:

- Environmental
- Source of Materials
- Containment
- Settlement
- Liquefaction of Fill
- Finished Grade & Transitions
- Utilities
- Inspection and Repair
- Construction/Cost/Schedule

Environmental - There are significant water/air quality environmental issues that require further analysis and evaluation to determine the impacts associated with water circulation, sedimentation, air emissions during construction, extent of practicable electric/LPG equipment conversions, or possible variance mitigation, and wind pattern changes. Of all the concepts, the air emissions from construction and marine operations are the greatest for the fill solutions. Fill structures can be constructed using dredge/barge operations or by land operations, including excavation from a local source with surface transportation and placement. The land operation is not considered practical from a cost and environmental standpoint and is not given further consideration in this report. Additional study and evaluation will be required to ascertain the influence of the fill structures on the hydrology and sedimentation of the Bay. The permit process associated with dredge, borrow and disposal areas, including the possible studies required to evaluate the impacts related to large quantities of dredging/disposal involved, may be very time consuming, thus impacting the time at which the new runways could be made operational. This also applies to concepts that are only partially fill and, consequently, these issues will have to be faced in any event. The possibility of not receiving permits also exists.

Source of Materials – To provide a stable embankment under water level, only sands or sands and gravels should be considered as fill materials. Fill source for this project should be considered from one or several sources, including those proposed by Consultants', from the San Francisco Bay and outside the Golden Gate, as well as more distant sources, such as the Mouth of the Columbia River or British Columbia Canada. The fill material sources presently proposed are not guaranteed as they must go through the permitting process and may be too fine grained. Concerns were expressed by the BRP that insufficient information was available on the availability, the gradation and other properties of sands in some of the proposed sources locations because of inadequate investigations. Hydraulically placed sand soils must be compacted to densities above the critical density to avoid liquefaction under seismic loading. Some fill sands may be difficult and expensive to compact to required density. For some proposed fill sources, a significant amount of YBM will first have to be removed from the borrow area and disposed of to uncover the sand fill material and/or to establish a re-handling basin for fill being brought into the Bay.

Containment - The perimeter retaining structure for all fill concepts are key components for overall stability of the structure for both static and seismic loading. An open cell sheet pile system as proposed by one consultant is not recommended due to concerns of performance under the large settlements anticipated and under major seismic events.

A perimeter rock dike is preferred but special design features should be incorporated in the design, including:

- Positive key-in of rock dike into the Young Bay Mud. This can be accomplished by dredging and disposal of some of the YBM under the dike.

- Install wick drains under the dike so primary consolidation will occur early.
- Construct rock dike with adequate side slopes on both sides to provide adequate stability.
- Install two to three layers of geotextile membrane, not only in the rock dike, but extended into the dredged fill to increase stability.
- Construct a graded filter between the rock dike and the dredged fill to prevent infiltration of the fines from the dredged fill into the rock dike.
- Construct the rock dike early around the platform before placing the dredged fill to reduce turbidity in the Bay.

Settlement – If a fill structure is constructed on top of the Young Bay Mud, large settlements can be expected. The major portion of the anticipated settlements caused by primary consolidation will occur during construction with the proper use of wick drains and surcharge. There will be some residual settlement due to secondary consolidation and creep in the fill after the runways are put in operation but these settlements can be accommodated with proper maintenance.

Liquefaction of Fill – Sand soils placed as dredged fill will be in a loose condition and subject to liquefaction during a seismic event. If the sands are compacted to densities equal to or greater than the "Critical Density", they will not liquefy under a seismic event. The sand placed below the water level can be compacted by vibration, and those placed above water level can be compacted by conventional methods. The finer sands are more difficult to compact under water than the coarser sands and may require repeated application of the vibratory forces and more time between applications. Some of the fine grain sand proposed for this project may require greater compactive effort and time. Research and additional testing may be required to determine the best method of compaction of dredged fill placed under water.

Finished Grade & Transitions – The finished grade of the existing airport is approximately Elevation 7.0 feet. Since there is no need to see under the surface to inspect the structure after an earthquake, the finished grade of the new construction can also be 7 feet, which is 14 feet below the pile or bottom-founded structure.

The existing runway platform structures at SFO are earth fill. If earth fill is used for the new structures, there will be no need to construct and maintain troublesome transition sections between different structure types.

<u>Utilities</u> – All utilities can easily be installed in earth fill structures using conventional construction methods. Utilities can also be relocated when required in an earth fill structure.

<u>Inspection and Repair</u> – Of all the concepts, the fill concepts are the easiest to inspect after a major seismic event. Repairs should not require any exceptional measures and can be accomplished quickly.

<u>Construction/Cost/Schedule</u> – All studies have indicated that the fill concept is less costly than any of the other concepts. Preliminary projections indicate that all fill concepts can be constructed within the 4 year project target for m A3 and 5 years for F2 and BXr. The fill concepts utilize about 30-60% of the labor required for the pile concepts.

<u>PILE STRUCTURES (PSS)</u>

The primary motivation for a pile supported structure (PSS) runway concept is the reduced environmental impact. Pile supported structures are expected to (1) require the least amount of dredging, (2) provide the least obstruction to currents and tidal flows in the San Francisco Bay, (3) are least disruptive to recreational activities in the Bay, and (4) have a low impact on on-site air emission standards during construction.

The key issues to consider further in the design development of the PSS runway concept are:

- Pile Spacing/Environmental Impact
- Seismic Performance

- Inspection, Maintenance and Repair
- Construction, Cost, Schedule

Pile Spacing/Environmental Impact - Initial perceptions are that a pile-supported structure would be more environmentally friendly than a fill structure with respect to Bay hydrology, sedimentation and wind patterns. However, further study and evaluation is required to ascertain long term differences relative to water circulation between fill and pile options, as initial indications are that there may be an accumulation of sediment under pile structures. Also, shoaling will occur in some areas with both fill and pile-supported structures but is not as well-defined for pile-supported structures. This must also be examined in more detail. The spacing of piles is also a consideration for water circulation. As a minimum, the spacing should be not less than 40 feet on centers each way. Some proposed pile-supported structures require a large amount of access dredging. Larger pile spacings will result in the least obstruction to water flows. On the other hand, larger pile spacings require larger diameter piles, longer deck spans, and deeper deck sections. From the preliminary design studies on PSS systems, pile spacings in the range of 40 to 60 feet with piles of 4 to 8 feet diameter seem to provide the best compromise between these competing issues.

Steel piles, cast-in-place concrete piles, and precast concrete piles were all proposed. For steel piles, based on cost, availability and durability, there is a question of whether the procurement would all be in the United States. Durability, maintenance, construction and cost issues indicate that concrete (precast or cast-in-place) piles may be advantageous. The use of prismatic concrete piles may be considered. The production of precast piles may have to be done by several producers to minimize the impact on their other customers.

Seismic Performance - A pile supported runway structure should be designed as a fully ductile structural system for seismic loads. The system should be designed such that the superstructure or deck remains elastic at all times while the large seismic design displacements are accommodated in the pile system through the formation of strategically located plastic hinges. Under the ULE the piles are expected to form inelastic mechanisms or plastic concrete hinges at the pile top below the superstructure soffit. These plastic hinges will see damage at the ULE design level in the form of cover concrete spalling, while the well confined concrete core stays structurally intact. A second inelastic mechanism can start to form in-ground (below the water and in the bay mud). However, the inelastic action in these in-ground mechanisms should be limited by design to levels at which strains are controlled such that no damage occurs and no inspection or repair are required. Since a full second in-ground plastic hinge would be required in addition to the top-of-the-pile hinge to form a full collapse mechanism, the proposed system provides a high level of seismic safety and reliability. Operational or functional limitations to the runway will come from possible large permanent lateral displacements of the entire runway deck and from damage to the expansion joints. The seismic design criteria for the project should limit the permanent off-set and make provisions for temporary and permanent expansion joint repair measures, consistent with airport operational requirements. The proposed seismic design concept limits damage to the column top location which is above water, and accessible for inspection and repair. Repairs can be performed under full runway operation. To ensure that the deck or superstructure remain undamaged, yield penetration from the pile plastic hinge into the deck needs to be controlled with special design details.

If a pile-supported structure is used, it should be used for the entire runway/taxiway platforms. There should be no transition sections from fill to piles within the runway platforms. For the superstructure supported by the piles, the expansion joints should be minimized and designed for both seismic performance and ease of repair after a major seismic event. Consideration should be given to using reduced safety factors for temporary loads during construction. Prior to final design, advanced driving tests or construction tests in the case of cast-in-place piles in the YBM must be performed. Load tests of the proposed piles are also recommended. The long-term settlements of the pile-supported structures in YBM are not well defined and need further examination. Temperature measurements of existing pile supported structures over water should be made to establish the influence of varying air and water temperatures on the thermal performance of the structure. The final paving surface on the superstructure should be a flexible pavement.

Inspection, Maintenance, and Repair - Due to the large number of piles in a PSS runway, provisions need to be made in the design for inspection, maintenance, and possible repair. Special instrumentation to monitor pile top conditions electronically should be considered. Inspection and repair procedures and measures following a major earthquake should be addressed and detailed as part of the final design.

Construction/ Cost/ Schedule - Construction of PSS runways should maximize off-site precasting, yet allow for generous construction and assembly tolerances to minimize overall risk in terms of cost and schedule. A flexible runway pavement consisting of 8 to 10 inches of bituminous overlay will be required to allow for grade corrections. The flexible overlay is also needed to allow for grooving to prevent hydro-planing, and the installation as well as re-location of operational signs and lighting. All utilities, including drainage, water, sewer, electrical and control, will be located within or under the deck or superstructure and need to be fully accessible.

The construction of the superstructure elements that will sit on top of the piles cannot be constructed in current production facilities in the Bay Area. A new-built casting facility will have to be established with water access for transportation of the precast concrete units. Establishment of this facility will require permitting which, in turn, could result in a need for substantial lead-time. The proposed schedules for pile-supported structures can meet the Airport's schedules, but the scale of the construction task must not be underestimated.

BOTTOM-FOUNDED STRUCTURE (BFS)

Bottom-Founded Structure (BFS) for runway construction should only be considered when environmental issues do not allow dredge and fill structures, and when airfield operations do not allow for the vertical clearances required for the construction of pile supported systems. Thus, a BFS should only be considered for the SFO runway expansion project for runway configuration F2 and runway 1L/19R. The BFS still requires significant dredge and fill operations, and requires a closer column spacing than the proposed PSS concept. Thus, the environmental benefits of a BFS may be limited and should be further evaluated.

Key design issues to be considered in the development of the BFS concept are:

- Environmental Impact
- Seismic Performance
- Long Term Settlements
- Construction/Cost/Schedule

Environmental Impact - The closer column spacing in the BFS will limit water circulation and result in increased sedimentation compared to the PSS with large pile spacing. Furthermore, the entire runway footprint needs to be dredged and filled prior to the installation of the precast float-in units. Detailed studies of the environmental impact of a BFS need to be conducted first to support the further development of this concept.

Seismic Performance -The seismic performance of a BFS is more complex since the reduced overall depth of the structure will make it difficult to accommodate the full seismic displacements in the structure. Thus, the concept of a sliding gravel layer fuse under the BFS has been proposed. This sliding seismic gravel layer fuse concept, while theoretically feasible, has significant uncertainties which result in a reduced seismic reliability of the BFS. The difficulty is in predicting the actual lateral force level at which fusing will occur in the gravel layer. Furthermore, it is uncertain how infiltration of the gravel layer with fine sands over time will affect the fuse level. In addition sedimentation around the footprint of the BFS and on top of the bottom slab can change the fuse force. Thus, in addition to the seismic fuse in the gravel layer, the BFS columns need to be designed for ductility through proper detailing of plastic hinge regions at both ends of the short columns. While the top hinge will be readily accessible for inspection and repair following an earthquake, the bottom hinge will be below water and with time below sedimentation, which will make inspection and repair difficult. Finally, to minimize seismic response problems, stiffness changes along the BFS segment connection lines should be avoided, which will require that not just the top slab but also the bottom slab be connected and made continuous.

Long Term Settlements - BFS runways are subject to long term settlements in the underlying bay mud and the design needs to address future grade corrections and adjustments. While the large BFS unit footprint will make individual BFS segments insensitive to differential settlements, the connection between segments needs to be designed to manage these settlement differences. Again, connection/continuity of the bottom slab should be one of the design considerations.

Construction/Cost/Schedule - While the BFS concept clearly has the advantages of off-site precast construction, and low required overhead clearance during installation, the preparation for the BFS substrate with dredging, fill, gravel fuse and below water grading presents added construction challenges. The proposed BFS elements cannot be constructed in current production facilities in the Bay Area. A new-built casting facility will have to be established with water access for transportation of the finished units. Establishment of this facility will require permitting which, in turn, could result in a need for substantial lead-time. The proposed schedules for a bottom-founded runway structure can meet the Airport's schedules.

PDF FILES (GENERAL REFERENCE – NOT PRIMARY REFERENCES)

ADEC

- *Preliminary Report #1*
  Existing Data and Issues
  (R1.06 – 270 Pages)

- *Preliminary Report #2*
  Conditions Assessment
  (R2.06 – 167 Pages) Nov. 99

- *Preliminary Report #2A (Task B1)*
  Geotechnical Site Characterization
  (Vol. 1 – Main Text, Figures & Maps – 160 Pages)
  (Vol. 2-A – Appendices A-F – 173 Pages)
  (Vol. 2-B – Appendices G-K – 316 Pages)

- *Preliminary Report #2C (Task B3)*
  Reconnaissance Sand Search Investigation
  (95 Pages, Maps A. B & C of borrow site)

- *Preliminary Report #3A*
  Water Circulation, Sedimentation & Coastal Studies
  (R3A.36 – 292 Pages, Dec. 99)

- *Preliminary Report #3D (Task D)*
  (Vol. 1 – Main Text & Figures – 267 Pages)
  (Vol. 2 – Appendices) R3D/D.06