FAQ ON SERATA STRESS TECHNOLOGY (SST)

1.0 SIGNIFICANCE AND BENEFITS

1-1 What are the Serata's basic inventions, which opened a new era of digital optimization earthwork?

1-2 What is the significance of SST innovation?

1-3 What are actual examples of the benefits proven in field?

2.0 APPLICATIONS

2-1 What kinds of work are best suited for Serata Probe?

2-2 What are the specific areas of application?

2-3 what are the main benefits of SST application to dam, slope and foundation projects?

3.0 FUNCTION OF SERATA PROBE

3-1 How does the Probe function?

3-2 What is the accuracy of stress measurement?

3-3 How is the accuracy verified?

4.0 WORK PREPARATION AND OPERATION

4-1 What is the mobility of the entire package of Serata Probe system?

4-2 What site preparation works is required to carry out a full-scale stress/ property measurement?

4-3 What is the time required for site setup?

4-4 What are common problems in site preparation for Serata Probe application and their solutions?

5.0 EARTHQUAKE TIME-PREDICTION

5-1 What is the justification of advocating time-prediction of forthcoming major earthquakes in contrary to common belief?

6.0 GENERAL INFORMATION

6-1 How can I get more detailed information?

6-2 How can I get service arrangement?

6-3 Why has Serata Probe taken so long to get global recognition?

6-4 How safe is the Probe application with the high-pressure system?

6-5 What is the difference between Serata Geomechanics, Inc. (SGI) and Serata Geomechanics Corporation (SGC)?

6-6 What are the requirements for a geotechnical company to be qualified as a licensed user/partner of SST?

1.0 SIGNIFICANCE AND BENEFITS

1-1: What are the Serata's basic inventions, which have opened a new era of digital optimization of earthwork?

They are the two proprietary techniques of earthwork optimization, i.e., Serata Method of in-situ stress/property measurements and SST method of earthwork modeling on-site. Serata Method has overcome the half-century impasse of accurate automatic stress/property measurement in complex inhomogeneous earth media, while SST method has achieved computer verification of earthwork behavior on site. It is an innovation achieved by integration of these two field developments that has suddenly opened a new era of digital optimization of earthwork.

1-2: What is the significance of SST innovation?

The significance is technological and economic gains to be secured by the innovation in major underground earthwork.

1-3: What are actual examples of the benefits proven in field?

The best examples are more than a dozen of failing salt and potash mines which were saved from their anticipated abandonment in US, Canada and EU (see <u>Category</u> 6). The savings ranged 0.25 to 1.0 billion dollars each. This is indicating the reasonable magnitude of benefits to be expected from the SST optimization in major earthworks.

2.0 APPLICATIONS

2-1: What kinds of work are best suited for Serata Probe?

It is best suited for major earthwork of any kind, in which computer optimization can be beneficial. Thus, the Probe is applied to survey, design, construction and safety assurance of earthwork in general as shown by the field examples in Category 3.

2-2: What are the specific areas of application?

The areas are mining, tunneling, dam, slope and foundation, underground space utilization, gas and oil storage and earthquake time-prediction. Their field application examples are illustrated in Categories 4 and 5.

2-3: What are the main benefits of SST application to dam, slop and foundation projects?

They are in two fields, i.e., 1) design optimization by creating in-situ verified behavioral models, and 2) monitoring aging deterioration of major earth structures with "<u>site proven</u>" computer model as function of time.

3.0 FUNCTION OF SERATA PROBE

3-1: How does the Probe function?

The Serata Probe measures stress state (S) and material properties (P) by observing force balance between the internal probe loading force and external earth stress. This proprietary principle (single-fracture method) makes automatic S and P measurements simple, fast, accurate and repeatable. Details of Probe function are described with laboratory and field verifications in Category 2; "Invention of Serata Probe". The superiority of the Probe over the conventional methods is itemized in Table 1-1.

3-2: What is the accuracy of stress measurement?

The accuracy is better than ± 2.0% for the first measurement, and this value is significantly improved by repeating the measurements as many times as needed at the same site. In contrast, accuracy of conventional stress-measurement methods is fundamentally limited to ±15% to ±30% due to Inhomogenuity of earth materials, which do not conform to the elasticity principle.

3-3: How is the accuracy of verified?

It has been verified first by systematic laboratory testing under the precisely controlled biaxial loading conditions. This was followed by field verification tests, made by utilizing known overburden weight as a test loading at the world famous Underground Research Laboratory of Atomic Energy of Canada, Pinawa, Manitoba. Details of the accuracy studies are presented in Category 2; "Invention of Serata Probe". Another verification is a nearly perfect agreement of the measured gradient of intrinsic lateral tectonic stress gradient with its theoretical value established by the Japanese government field test program. The measurement results are presented in Fig. 5-3 in Category 5.

4.0 WORK PREPARATION AND OPERATION

4-1: What is the mobility of the entire package of Serata Probe system?

It is highly mobile, as the whole system weighs about 115 kg (250 lbs). The package is easily carried around the world as ordinary travel baggage in flight. A small station wagon is adequate for on-land transportation. In the underground it can be conveniently carried around by two people.

4-2: What site preparation works are required to carry out a full-scale stress/property measurement?

The works are:

1) Test holes: freshly drilled test holes with I.D. 66mm ± 1 mm are required for the ground to be measured. A single test hole can be utilized repeatedly for indefinite period of time with a proper care.
2) Power supply: Line power 110V or 220V AC (50 or 60 cycle) or an auto battery set delivering 12V DC is required. The auto battery is found most convenient because the time for each single measurement is very short (10 ~ 15 minutes).
3) Work seat: A level area of 1m x 5m is required for measurement station setup.

4-3: What is the time required for site setup?

The required set-up time is less than an hour after the Probe package (115kg/250 lbs.) is delivered to a test site. One se of stress/property measurement requires up to 15 minutes, once the Probe is mounted in the test hole.

4-4: What are common problems encountered in site preparation for Serata Probe application and their solutions?

They are three basic problems. One is proper ventilation for drilling. Second is test hole preparation, which should be arranged in advance. Third is long-term maintenance of the hole for a permanent use. These problems have been resolved by adaptation of simple field practices.

5.0 EARTHQUAKE TIME-PREDICTION

5-1: What is the justification of advocating time-prediction of forthcoming major earthquakes in contrary to the common belief?

The justification is an outcome of the Serata's three and half decades of extensive underground stress measurement work made possible through inventions, discoveries and global data analysis in geomechanics. The outcome is summarized below in time-sequence of the development, starting from invention of Stress Probes, formulation of earthquake stress mechanism through field verifications to the development of geomechanical methodology for earthquake time-prediction.

1) Inventions of direct in-situ stress/property measurement systems

   The proprietary methods of simple direct in-situ stress/property measurement system (Double-Fracture Method and single-Fracture Method) have been successfully invented, enabling us to measure time-dependent changes in underground stress state and material properties automatically and repeatedly on-site in real-time. This has successfully eliminated the formidable difficulties of the conventional methods of stress and property measurement. Details are summarized in Category 1 (Table 1-1).

2) Verification of earthquake triggering mechanism

Accidentally, Serata triggered a series of the world's largest man-made earthquakes (M ≅ 5.0) during a large-scale extraction of the deep underground potash deposit in Saskatchewan, Canada in 1982. With reduction of magnitude of the earthquake triggering stress in the critical ground by 15%, the repeating earthquakes were suddenly stopped and completely eliminated within eight months without abandoning the large-scale extraction. This had decisively demonstrated the direct cause of the earthquakes in quantitative terms of geomechanics. Details are given in Category 5 (Fig. 5-1).

3) Invention of Serata Probe to overcome impasse of inhomogenuity

Accurate in-situ stress measurements by the conventional methods have been proven impossible because of Inhomogeneity of the earth media. This fundamental barrier against accurate earthquake stress measurement has been totally eliminated by the latest invention of Serata's Single-Fracture Method of stress measurement. The details are presented in Categories 1 and 2 (Summary in Table 1-1).

4) Discovery of intrinsic depth gradient of lateral tectonic stress

The intrinsic depth gradient of lateral tectonic stress ($\tan \theta = 0.25$) was discovered accidentally by Serata Probe in the Japanese government stress testing program at Mr. Fuji Test Site in 1984 (Fig. 5-3). This finding was proven to be in a nearly perfect agreement with the basic geomechanics principle of lateral tectonic stress state. This discovery has been proven to prevail globally with no exception. It is this global discovery that has established our geomechanical basis to monitor earthquake shear stress (Figs. 5-5, 5-6 and 5-7) for the time-prediction of forthcoming major earthquakes.

5) Formulation of earthquake stress cycling with earthquake stress head

The dynamics of earthquake shear stress cycling is analyzed and its basic geomechanics principle is formulated as illustrated in Figs. 5-11 and 5-12. The significance of this principle is recognition of rising earthquake shear stress up to top of the tectonic plate forming the "Earthquake Stress Head" prior to earthquake failure of the ultimate stress nucleus. This is the fundamental simple process of the stress nucleus failure as illustrated in Figs. 5-1, 5-11 and 5-12. This principle has been field tested quantitatively in the Japanese government stress testing programs conducted at the two famous earthquake sites as illustrated in Fig. 5-15. The geomechanical principle should be closely related with the precursor of electro-magnetic interference established by Y. Kushida and the precursor of borehole micro-deformation established by H. Ishii as illustrated in Fig. 5-13.

Here, shear stress head to be monitored by Serata Probe is superimposed by an imagination simply to illustrate a possible three precursor relationship expected to occur at every major earthquake site. This remains to be verified in future.

6) Mechanism of time-prediction method

Serata Stress Technology (SST) is made useful by the recent seismological advancement made on site-prediction of forthcoming major earthquakes. As a result of the advancement, a number of sites required for the stress measurements is getting very small, limited only at sites of rising earthquake stresshead as illustrated in Fig. 5-13. Here, the rise of the head (τ_o^E) value must be related to certain seismological phenomena, which are getting recognized in the recent studies.

7) Economics of earthquake stress monitoring

Contrary to the common belief, the τ_o^E monitoring can be made economically as it requires only small (ϕ = 56mm) and shallow (600m ~ 800m) test holes. The required frequency of monitoring is usually no more than once a year (less than a day), except at a site of imminent major earthquake. Wherever such site (τ_o>35MPa) is detected, a continuous monitoring is carried out simply and economically with the automatic stress measurement frequency of more than 100 times a day as illustrated in Fig. 5-13. Therefore, it is difficulty to justify the avoidance of looking into a basic relationship between the seismological and geomechanical findings for the common goal of accurate (digital) time-prediction.

8) Recognition of SST for time-prediction

The first recognition of the SST method was made by the Japanese government immediately following the Kobe earthquake of 1995. This has led to the current long-term national program made by a collaboration of the Earthquake Research Institute of University of Tokyo and the government Earthquake Research Institute of AIST. The Earthquake Bureau of the Chinese government in Beijing is expressing their interest, but it is still in a talking stage. In USA, we are advised by NASA to secure a long-term NSF instrument research grant so that NASA can use a most advanced Probe for their future time-prediction program.

6.0 GENERAL INFORMATION

6-1: How can I get more detailed technical information?

The detailed information on the Probe and Technology is comprehensively presented in the following seven Categories in this site.

1. Overview of New Era

2. Invention of Serata Probe
3. Field Verification of Serata Technology
4. Earthwork Application Examples
5. Accurate time-Prediction of earthquakes
6. Global Project Records and References
7. Services

6-2 How can I get service arrangement?

If you find SST interesting and applicable to your operation, you should try it out in your fieldwork first. We are able to cooperate for you to experience the power and benefits of SST in your operation. A field promotion program can be designed with a small expense by devising the program to generate sufficient economic gains to easily cover the cost. This type of mutual support program is the manner that has been successfully used to develop SST globally as illustrated in the field examples given in the website (Category 6: Global Project Record and References). In the future, should you find SST truly beneficial to your operations, there is possibility for you to become a member of our franchised global network of SST Services. The network will be developed by partnership of major construction companies as well as small geotechnical consulting companies. Technical and financial successes of the partnerships will be assured by Serata's backup with whatever support is necessary to achieve our joint goals. Operation plans will be jointly engineered for your best interests.

6-3: Why has Serata Probe taken so long to get global recognition?

The reason is the time-consuming effort required to overcome difficulties with the elasticity assumption, on which the original Serata Probe (Double-Fracture Method) was based. It took more than two decade of intense R&D work to replace the fallacious elasticity assumption of earth media with the newly invented force balance principle (Single-Fracture Method) to completely overcome the impasse of half-century.

6-4: How safe is the Probe application with the high-pressure system?

Over the past three decades of Probe operation in many countries, we have never had any accidents nor bodily injuries. Standard safety precautions are required.

6-5: What is the difference between Serata Geomechanics, Inc. (SGI) and Serata Geomechanics Corporation (SGC)?

Each has a different role for the global network operation. SGC is newly established as a franchised field service organization while SGI will remain as the basic R&D company to provide technological backup to SGC.

6-6: What are the requirements for a geotechnical company to be qualified as a licensed user/partner of SST?

The principal requirements are as follows.

1) Having an established engineering practice with staff qualified to operate Serata Probe in your operation.
2) Having at least two qualified engineers who pass the SST qualification test after completing basic SST training.
3) Having a strong desire to lead in optimization of earthwork in the areas of your operation.
4) Willingness to shear your SST field data with other partners of our global network to maximize the franchised network.

For more details, go to "Services" in this site or contact Shosei Serata by sending e-mail (serata@serata.com) or call at (510) 659-8630/ (510) 797-4228.