Value of STRAAM Dynamic Assessment

STRAAM provides a detailed measure of structures dynamic properties. These properties are integral to how a structure will perform and are addressed in the International Building Code, through the design standards in ASCE 7-10 (herein referred as the 'code'). The intent of the design considerations is to yield a certain level of performance for the building, therefore our measurements help quantify how the building actually performs compared with the standard. We address these concerns by taking measurements of the structure for comparison to see if the design intent was met. The Dynamic Signature includes the following:

Frequency measurements – This establishes the stiffness of the structure in various modes of vibration. There is an absolute minimum requirement for the first mode in the code. Higher order modes are identified as well. Also addressed in the code is identifying higher modes that contribute to 90% of the contributing modal mass.

Modes shapes – By measuring mode shapes, we identify areas of weakness or lack of stiffness. The code clearly defines concerns about irregularities. The mode shapes relates to these concerns.

Displacements – ASCE 7-10 requires buildings to meet serviceability requirements. Although the standard is vague, there are well established norms for this performance criterion.

STRAAM Experience – We have developed a sophisticated platform of hardware and software embedded with proprietary algorithms to provide these assessments to take this service to the market on a broad level. We provide the best equipment available to capture these measurements to achieve accurate results. Additionally, Dr. Jeary of STRAAM is recognized as a world expert in the field of structural dynamics with over 300 peer review papers relating to the subject. We have a data base of nearly 1000 structures and have advanced algorithms to process the data accurately and efficiently. No other company has the level of experience in measuring a building's response with the advanced techniques used by STRAAM Group.

3rd party validation – It's advisable to have a third party with the appropriate credentials perform this service. Other less qualified companies can claim to provide these measurements, however, it is very unlikely they have the experience STRAAM does, nor can they deliver the non-linear response information which is essential for quality results. Having this test completed by a 3rd party is essential to providing objective validation as with any testing completed on a structure.

Specific ASCE 7-10 sections which apply

Chapter 12

12.1.1 Basic Requirements

The seismic analysis and design procedures to be used in the design of building structures and their members shall be as prescribed in this section. The building structure shall include complete lateral and vertical force-resisting systems capable of providing adequate strength, stiffness, and energy dissipation capacity to withstand the design ground motions within the prescribed limits of deformation and strength demand. The design ground motions shall be assumed to occur along any horizontal direction of a building structure. The adequacy of the structural systems shall be demonstrated through the construction of a mathematical model and evaluation of this model for the effects of design ground motions. The design seismic forces, and their distribution over the height of the building structure, shall be established in accordance with one of the applicable procedures indicated in Section 12.6 and the corresponding internal forces and deformations in the members of the structure shall be determined. An approved alternative procedure shall not be used to establish the seismic forces and their distribution unless the corresponding internal forces and deformations in the members are determined using a model consistent with the procedure adopted.

12.3 DIAPHRAGM FLEXIBILITY, CONFIGURATION IRREGULARITIES, AND REDUNDANCY

12.3.3.2 – Horizontal structural irregularities   pg. 125

1a   1.2 x   STRAAM   - Mode shapes would identify if there is a stiffness anomaly. If there is a significant variation in the mode shape, further investigation may be needed. .

1b   An extreme irregularity would show up in the mode shape as discussed above.   'Soft stories' is an important issue in California due to failures in the past during earthquakes.

12.3.3.4 Increase forces

12.8.2   Section 12.8.1 gives a methodology for the seismic response coefficient, and specifies a maximum value for design, that does not need to be exceeded. Since the C_s value is inversely proportional to the fundamental period of the structure this effectively stipulates a maximum value for the period for any particular design. Allowable formulae for the calculations are listed. Various parameters are allowed to account for materials and structural type, and acceptable formulae for the calculation of the period are listed. Additionally, in section 12.8.6.2 the acceptable drift limits it is permitted to assess the elastic drift based on the fundamental period of the building. Again, this implies a maximum period that is acceptable, but in this case it is concerned with the behavior of the building in the elastic range. The maximum allowable drift is directly specified in table 12.12-1

12.8.6   Drift – Irregularities.

- deflection amplification factor
- torsion amplification factor.

12.8.6.2 Period is used for computing drift. STRAAM measures the period which is used in this calculation. If the assumption for the period is incorrect, then this will be incorrect as well.

** 12.9.1 Higher order modes – Must exceed 90% of modal mass. STRAAM measures these modes of vibration.

12.9.3 Combine response factor pg. 137 This section (12.9.3) considers the difficulties with modes of vibration that are close in frequency. The effects are difficult to consider at the design stage, but STRAAM measures them directly, including the effects of interaction.

12.9.4 Base shear is calculated from period. If the period is assumed incorrectly, then this very important aspect will also be incorrect.

Chapter 15

15..4.4 Stiffness , strength and ductility.

Fundamental period for non-building pg 188 (Section 15.4.4) For non-building structures, the fundamental frequency can be calculated using standard mechanics equations – in other words the period is 2 PI times square root of mass upon stiffness).

Chapter 18

This section considers hysteresis and viscous damping. Inherent damping shall not be larger than 5% just below yield (18.6.2.1). In practice it can be much smaller. We measure it.

18.6.2.1 Inherent damping – damping just before yield.

18.6.2.3 viscous damping is defined as a modal parameter. In practice it is 'equivalent viscous damping' otherwise the damping value would be zero as no energy would be dissipated.

18.6.3 Effective ductility demand. In this case the - period is part of the equation. Knowledge of the period of the entire structure is essential for this calculation.

18.8

Chapter 19 – Design review Seismic design – soil

19.2.1.1 Effective period calculation. Again, getting the period correct is important due to its influence in other calculations. Measuring it the only way to get it right.

Wind – Chapter 26

In section 26.9.3 acceptable formulae for the lower bound value of the fundamental natural frequency of a building are given. The formulae are based on the materials used for the building, and the structural type. Additionally, the height and dimensions of the building contribute to the calculation. These procedures are valid for buildings less than 300 feet tall and with an aspect ratio of four or less. This effectively states that there is a minimum acceptable fundamental natural frequency for the design to meet the Standard.

Appendix 11B - Alterations to buildings requires that the structure must meet code.

Additional references

Pg 420 - Strength is important <u>but not independent of stiffness</u>. (Chapter C1 of the commentary) C1.3.1.

Pg 423 – Process through peer review- STRAAM could be a method.

Section C1.3.1 talks about a move towards performance criteria in which both serviceability and structural integrity are mentioned (STRAAM fits here very well).

Pg 536 – References ACI. .35% is references there. Elastic limit. (Chapter C14)

Pg 567 – references natural frequency estimates from all over. 46(150')/h Chapter C26.9)