ment, these works include a diverse range of other struc tures such as quay walls, bridges, supporting structures for energy piping, and the like. Since the guidelines and standards to which these structures conform also differ,

This method to predict earthquake damages contributes to an effective investment.

1. Introduction

inet Off ce, Government of Japan) and the Headquarters

tion, Culture, Sports, Science and Technology), and seis mic retro f tting of buildings and equipment against these

in the business continuity plans (BCP) of steel works.

In order to realize reasonable seismic retro f tting, accurate prediction of how expected earthquakes will propagate and arrive is necessary. For this, an accurate assessment of the local strata is critical. On the other hand, multiple steel works exist in different regions, and unifying target seismic strength levels company-wide. This paper describes recent and advanced techniques for predicting strong ground motion (Chapters 2–4) and an earthquake prediction method for structures which is re f ected in various design standards (Chapter 5).

2. Expected Earthquakes

In studies of damage prediction, f rst, it is important to select the large-scale earthquakes which should be assumed. As such earthquakes, the results of a recent survey[1)] of the national government and local govern ments identi f ed (1) historical earthquakes which are considered to have affected the subject area in the past, (2) earthquakes having an active fault as the hypocenter, and (3) subduction zone earthquakes, among others. The main expected earthquakes are shown in **Fig. 1**. The earthquake which is thought to have the largest impact was selected for each region where steel works

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importance of the steel works structures, and other fac tors.

3. Earthquake Damage Prediction Methods

3.1 Outline

The methods generally used to obtain seismic wave for damage prediction were a method using a wave ampli fed to the expected maximum acceleration level based on the observed seismic wave in the past[2)]
method using a simulated seismic wave which satis fed a target spectrum prepared so as to envelope the mean or maximum values of the response spectra of several [3)], among others.

However, even among earthquakes with the same intensity level, the seismic wave will differ depending

response will differ corresponding to the characteristics of individual structures. Therefore, it is considered nec

of a steel works at the ground surface, and the purpose

analysis for individual superstructures. The stochas tic Green's functions method considers empirical site-specifc amplifcation and phase characteristics and has been adopted in design in the port and harbor feld.

The stochastic Green's function method is a tech nique in which the source fault is divided into mesh-like

Simplifed Method 1, a tendency could be seen in which *G (f)* was large on the short period side (i.e., the amplif cation ratio was high), and small on the long period side.

Here, in order to assess the effect of the differences

ground motions were prepared using the site amplifca tion factors obtained by the respective methods, and a [9] was carried out for a model steel sheet pile type quay wall[10] **Fig. 9**) at Port A, which was damaged in the 1983 Nihonkai-Chubu Earth quake. Reproducibility of actual earthquake deformation using this model has been confrmed. **Figure 10** shows the condition of deformation of the quay wall and the distribution of maximum shear strain.

In the analysis results using Simplifed Method 2, it

mation was reduced to approximately 70% in compari son with Simplifed Method 1. As the reason for this difference, although the maximum acceleration of the scenario earthquake estimated by Simplifed Method 2 was larger, the long period component under 1 Hz was

wall deformation.

Since the difference in the site amplifcation fac tors have a large effect on scenario ground motions, as illustrated above, a reevaluation using scenario ground motions refecting the results of seismic observation was carried out for some critical structures.

5. Evaluation of Seismic Capacity of Structures

5.1 Example of Detailed Dynamic Analysis

The chapter describes evaluation of seismic capacity for individual structures using scenario ground motions prepared by the method described] Mb

design is shown in **Fig. 12**, together with various stan dards. In this example, the maximum response velocity is set at 1 000 Gal, which is equivalent to an extremely C_0=1.0) in the Building Standard Law. On the long period side, this was decreased cor T≥2 s so as to be above the envelope of the expected Tonankai-Nankai earthquake. The slope of this decrease conformed to Level 2 seismic motion, Type I (marine type) in the Speci f cations for Highway Bridges. On the other hand, on the short period side, the maximum response velocity was decreased in conformance with the envelope of an expected Geiyo earthquake, which is predominant in the T≤0.4s. However, as the lower limit, 500 Gal T=0.1s) was adopted. This is equivalent to a Level 2 earthquake in the Guidelines based on the Japan Gas Association[13].

Response exceeding the set response spectrum for standard design appears partially in the vicinity of T=0.6s. Therefore, for structures with natural periods around this value, a dynamic analysis was used in com bination with the method described above, based on individual checks of the ground characteristics at instal lation locations.

Selection of equipment and structures which required

formed by a simple static evaluation using the response

thereby improving the ef f ciency of evaluations of seis mic capacity for diverse types of structures.

5.3 Application of Scenario Ground Motion to I_s

According to Noti f cations No. 184 and 185 of the

ism in 2006 based on the enactment of the Law for