Seismic Ground Response Analysis

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Seismic Ground Response Analysis

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Preface

Earthquake resistant design is an important consideration for designing structures in seismic prone areas including Japan. Recently, following the developments in seismology and earthquake engineering, design earthquake motion is defined at the engineering seismic base layer (engineering bedrock) or the seismic bedrock regardless of the structural type and the ground type. Therefore, in order to get the design earthquake motion at the ground surface or at the foundation of a structure, engineers need to make a seismic ground response analysis.

I graduated from the Department of Architecture and Architectural Engineering, Kyoto University (Japan), and my thesis for doctor of engineering was cyclic behavior of steel braces subjected to earthquake loading. Several years after my post-doctoral life in the university, I joined Sato Kogyo, a general contractor firm, and I engaged in the design of the RCWS (reactor cooling water system) of a nuclear power plant. There, I faced a problem on how to consider the liquefaction of the crushed rock that was used to fill the excavated area during construction just neighboring the grit chamber. I visited Prof. Ishihara, University of Tokyo, to get an idea. He introduced a computer program YUSAYUSA and I engaged to improve it with him, which is now open for public from my website (Yoshida and Towhata 1991), and it was my first technical paper in this field. Soon after, Prof. Ishihara introduced me to Prof. Finn, University of British Columbia, Canada, and I got a chance to stay with him for 1 year. I engaged to develop the computer code TARA-3 (Finn et al. 1986). After coming back to Japan, I decided to change my research topic from structure to geotechnics, especially earthquake geotechnical engineering.

There were many differences between the structure and the soil as engineering materials and I was sometimes overwhelmed by these differences. Why, for example, stress-strain curve is expressed by, so-called, G-γ and h-γ relationships, and why just an approximated method is called an equivalent linear method, etc. Modeling the stress-strain behaviour was not a big issue in structural engineering, but it was a big issue in the new field. The error of the analysis was very large compared with the one in my former field. Things that are believed to be common sense looked curious to me. So, it was a new world for me and I believed that I could contribute something in this field, which is the reason why I decided to move to the earthquake geotechnical engineering.

I started as an academician in the university several years ago quitting my second practical engineering job in Oyo Corporation, a consulting company. I was surprised that there is no time to teach the seismic ground response analysis in the syllabus. There are many topics that should be taught in the university, but time is limited. Seismic ground response analysis is a difficult issue because all other issues taught are necessary in order to understand the behavior during an earthquake.

On the other hand, seismic ground response analysis is an essential tool for the practical engineers. Then I had a question how they study this subject. Just that time, I was asked a lecture titled “seismic ground response analysis for practical use” from Prof. Wakamatsu, Kanto Gakuin University, who was a board member of the Japan Association for Earthquake Engineering (JAEE). Fortunately, the lecture was successful such that the JAEE turned away many people as the room became full. Then I understood that practical knowledge is desired from the practical engineer.

I published a book in Japanese in 2010 (Yoshida 2010) on the seismic ground response analysis based on this lecture. There are already many books on this subject. I feel, however, that there is no book that gives the knowledge or techniques required by the engineering practice or that the engineer can refer in their daily job. Many books deal with only the theoretical field, but there are many issues that cannot be discussed only by theory. So I especially focused on these topics. Soon after the publication of the Japanese book, Prof. Ansal and Dr. Tönük, Bogazici University, Turkey, suggested me to write an English version of this book. I omitted many theoretical descriptions in the Japanese version, but I think it would be better to add some theoretical parts for the foreign readers, which was also a suggestion by Dr. Tönük. So this is quite a new book.

This book deals with the total stress analysis, and the effective stress analysis or the liquefaction analysis is not considered partly because the effective stress analysis is more difficult compared with the total stress analysis and partly because another volume may be required to write the introductory part of the liquefaction analysis.

The author wishes sincere thanks to Prof. Wakamatsu who gave a chance to publish the Japanese book, and Prof. Ansal and Dr. Tönük who suggested the English version. Thanks are extended to Drs. Ohya, Port and Airport Research Institute, and Dr. Miura, Oyo cooperation, for their pre-reading of the Japanese version. Thanks are also extended to Dr. Tönük and Prof. Bhattacharya, University of Surry, UK, who checked my English.

Notes for Reading This Book

This book follows SI unit system (Promotion committee of SI unit 1999). In other words, kN, m, and s are used for force, length, and time, respectively. Unit for pressure is expressed by kPa instead of kN/m^2. In the field of seismology, Gal

(gal) has been used for acceleration, but it is not used in this book although it is possible as exceptional treatment. In the same manner, kine has been frequently used for velocity, but is not used in the book, either, because it is a non-SI unit. When converting the old unit system into the SI units, acceleration of gravity g is usually taken as 9.8 m/s^2, but 10 m/s^2 can also be used. Error of 2 % appears by this interpolation, but it is an acceptable error in many fields of engineering.

All the figures and equations are given using the SI unit. In the field of the geotechnical engineering, many empirical equations have been developed, and they are usually valid only in the specified unit. They are also rewritten in the SI unit system in this book.

Recently, information and data are published not only in the technical paper but also in the website. Here, unlike the technical paper, contents of the web are sometimes revised or erased, in which case the reader cannot find the data. In this book, the valid date of the existing website is shown in brackets [ ].

Abbreviations are used for several Japanese organizations which appear frequently in this book. They are as follows

AIJ:	Architectural Institute of Japan
JAEE:	Japan Association for Earthquake Engineering
JGS:	Japanese Geotechnical Society
JSCE:	Japan Society of Civil Engineering
JSSMFE:	Japan Society of Soil Mechanics and Foundation Engineering, renamed JGS in 1995
PARI:	Port and Airport Research Institute
PWRI:	Public Work Research Institute

Sendai, Miyagi, Japan Nozomu Yoshida

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Contents

1 **Propagation of Earthquake Waves in the Ground and Fundamentals of Earthquake Motion** 1
1.1 Wave Propagation from Source to the Site 1
1.1.1 Path of Wave Propagation and Analysis Region 3
1.1.2 Path of Body Wave Propagation 5
1.2 Amplification of Earthquake Wave 6
1.2.1 First Mechanism: Change of Wave Velocity 6
1.2.2 Second Mechanism: Reflection at the Ground Surface ... 7
1.2.3 Third Mechanism: Reflections from Underlying Layers 8
1.2.4 Fourth Mechanism: Resonance 9
1.2.5 Example of Earthquake Motion Amplification 11
1.2.6 Amplification of P-Wave 13
1.3 Attenuation of Earthquake Wave and Upper Bound Earthquake Motion 15
References 20

2 **Introduction of Seismic Ground Response Analysis** 23
2.1 Brief History of Seismic Ground Response Analysis 23
2.2 Procedure of Seismic Ground Response Analysis 25
References 28

3 **Input Earthquake Motions** 31
3.1 Engineering Seismic Base Layer 31
3.2 Historical Earthquake Motions 36
3.3 Intensity of Design Ground Motion 38
3.4 Synthesized Earthquake Motions 40
3.5 Strong Ground Motion Databases 41
References 42

4 Fundamentals of Soil Mechanics 45
4.1 Stress and Strain 45
4.1.1 Positive Directions of Stress and Strain 45
4.1.2 Effective Stress Principle 47
4.2 Characteristics of Soil Behavior 48
4.2.1 Volume Change 48
4.2.2 Shear Deformation 49
4.2.3 Other Parameters 49
4.2.4 Dilatancy 50
4.2.5 Constitutive Relations for Elastic Behavior 51
4.2.6 Confining Stress Dependency 53
4.3 Nonlinear Characteristics 54
4.3.1 Nonlinear Characteristics Against Shear 56
4.3.2 Nonlinear Characteristics Under Volumetric Change 56
References 58

5 In Situ Soil Testing 61
5.1 Standard Penetration Test 61
5.1.1 Energy Correction 62
5.1.2 Effective Confining Stress Dependency 63
5.2 PS Logging 65
5.3 Other Methods 67
5.4 Geological Age of Soil 68
5.5 Continuity of Soil Layers 69
References 71

6 Laboratory Test and Assemble of Test Result 73
6.1 Soil Sampling 73
6.2 Physical Tests 74
6.3 Cyclic Shear Deformation Characteristics Test 75
6.4 Test Apparatus 77
6.4.1 Cyclic Triaxial Test 78
6.4.2 Cyclic Direct Simple Shear Test 79
6.4.3 Cyclic Torsional Shear Test 80
6.5 Effect of Sample Disturbance During Sampling and Traveling 81
6.6 Compilation of Test Results 85
6.6.1 Hardin–Drnevich Model 85
6.6.2 GHE Model 87
6.6.3 Comparison of H-D Model and GHE Model 90
6.6.4 Double Hyperbolic Model 90
6.6.5 Confining Stress Dependency 91
6.7 Applicability and Limitations of Cyclic Shear Test 92
6.7.1 Strain Range and Accuracy of Test 92
6.7.2 Effect of Excess Porewater Pressure Generation 94
6.7.3 Effect of Loading Speed 98
6.7.4 Damping Characteristics 102

6.7.5 Cyclic Shear Deformation Characteristics and Shear Strength ... 105
6.7.6 Behavior at Large Strains ... 106
6.7.7 Effect of Number of Loading Cycles ... 109
6.7.8 Initial Stress and Its Effect to Analysis ... 111
References ... 114

7 Estimation of Mechanical Soil Properties ... 119
7.1 Elastic Properties ... 119
7.1.1 Equation by Imai et al. ... 120
7.1.2 Evaluation by Japan Road Bridge Design Specifications ... 121
7.1.3 Equations Developed for Port Facilities ... 122
7.1.4 Equations Frequently Used in Buildings Design ... 123
7.1.5 Equations by Iwasaki et al. ... 124
7.1.6 Equations Based on Laboratory Tests ... 125
7.2 Nonlinear Properties ... 129
7.2.1 Equations by PWRI ... 130
7.2.2 Equations Involved in Technical Standards for Port and Harbor Facilities ... 135
7.2.3 Equations Involved in Standards for Railway Structures ... 137
7.2.4 Equation in Building Standard Law ... 138
7.2.5 Equation by Central Research Institute of Electric Research Industry ... 138
7.2.6 Study Compiled by Seed and Idriss ... 141
7.2.7 Equation by Yasuda et al. ... 142
7.2.8 Study by Vucetic and Dobry ... 144
7.2.9 Study by Oyamada et al. ... 144
7.2.10 Study by Imazu and Fukutake ... 145
7.2.11 Study by Fukumoto et al. ... 148
7.2.12 Study by Wakamatsu et al. ... 151
7.2.13 Remaining Literatures ... 151
7.3 Behavior Under Large Strain: Shear Strength ... 152
7.3.1 Shear Strength of Sand ... 155
7.3.2 Shear Strength of Clay ... 158
7.4 Other Parameters ... 160
References ... 161

8 Modeling of Mechanical Soil Properties ... 167
8.1 Elastic Modulus ... 167
8.1.1 Elastic Shear Modulus ... 167
8.1.2 Bulk Modulus and Poisson's Ratio ... 169
8.2 Nonlinear Model for One-Dimensional Analysis ... 173
8.2.1 Relation Between Cyclic Shear Deformation Characteristics and Mathematical Models ... 173

- 8.2.2 Hysteresis Rules ... 175
- 8.2.3 Hyperbolic Model ... 179
- 8.2.4 Ramberg–Osgood Model ... 182
- 8.2.5 Yoshida's Model ... 187
- 8.2.6 Modified GHE Model ... 190
- 8.3 Constitutive Models for Multidimensional Analysis ... 190
  - 8.3.1 Extended Model from One Dimension ... 190
  - 8.3.2 Plasticity Theory ... 194
- 8.4 Choice of Models and Evaluation of Parameters ... 198
- 8.5 Complex Modulus ... 200
- References ... 202

9 Equation of Motion ... 205
- 9.1 Equation of Motion and Wave Propagation ... 205
- 9.2 Multidimensional Analysis ... 207
- 9.3 Back Analysis ... 210
- 9.4 Multiple-Support Excitation ... 211
- References ... 213

10 Equation of Motion: Spatial Modeling ... 215
- 10.1 Modeling of Analyzed Region ... 215
- 10.2 Irregularity of Ground ... 216
  - 10.2.1 Dimension ... 216
  - 10.2.2 Lens Shape Irregularity ... 218
- 10.3 Size of Layer Thickness and Mesh ... 219
- 10.4 Boundary Conditions ... 222
  - 10.4.1 Lateral Boundary ... 223
  - 10.4.2 Base Boundary ... 227
- 10.5 Multidimensional Analysis ... 230
  - 10.5.1 Consideration of Vertical Motion ... 230
  - 10.5.2 Mass Distribution ... 231
  - 10.5.3 Shape and Configuration of Element ... 232
  - 10.5.4 Integral Points, Volume Locking, and Hourglass Instability ... 234
- 10.6 Initial Conditions ... 236
- References ... 239

11 Solution in Time ... 241
- 11.1 Time Domain Analysis ... 241
  - 11.1.1 Numerical Integration Scheme ... 242
  - 11.1.2 Stability of Numerical Integral ... 249
  - 11.1.3 Choice of Numerical Integration Scheme ... 252
- 11.2 Frequency Domain Analysis ... 254
- 11.3 Multiple Reflection Theory ... 257
- 11.4 Equivalent Linear Method ... 260
  - 11.4.1 Method in SHAKE ... 261
  - 11.4.2 Limitation of SHAKE ... 263

11.4.3 Improvement of SHAKE 266
11.4.4 Equivalent Linear Analysis in Time Domain 272
11.4.5 Nonlinear Method and Equivalent Linear Method 272
References 274

12 Evaluation of Damping 277
12.1 Hysteresis Damping 277
12.2 Velocity Proportional Damping 278
12.2.1 Rayleigh Damping 278
12.2.2 Mode Proportional Damping 282
12.3 Wave Scattering 284
12.4 Radiation Damping 290
12.5 Numerical Damping 290
12.6 Damping as Alternative 291
References 292

13 Evaluation of Accuracy and Earthquake Motion Indices 295
13.1 Acceleration, Velocity, and Displacement 296
13.2 Seismic Intensity Scale 299
13.3 Spectral Intensity 300
13.4 Spectrum 301
13.5 Other Quantities 304
References 305

14 Simulation of Vertical Arrays 307
14.1 Applicability of Equivalent Linear Method 307
14.2 Response at Medium Strain 312
14.3 Response at Large Strains 317
14.4 Problems in Setting Elastic Modulus 320
14.5 Effect of Layer Thickness and Choice of Property 323
References 327

15 Effect of Various Factors from Case Studies 329
15.1 Scattering of Nonlinear Property 329
15.2 Scattering of Wave Velocity 330
15.3 Past Blind Tests 332
15.4 Pulse Waves as Result of Numerical Integration 333
15.5 Equivalent Linear vs. Truly Nonlinear 338
15.6 Determination of Damping for Deep Bedrock Problem 343
15.7 Role of Hysteretic Damping Term 344
15.8 Location of Engineering Seismic Base Layer 349
15.8.1 Problem to Separate at Engineering Seismic Base Layer 350
15.8.2 Setting Design Earthquake Motion 357
15.8.3 Remarks 361
References 362

Index 363