

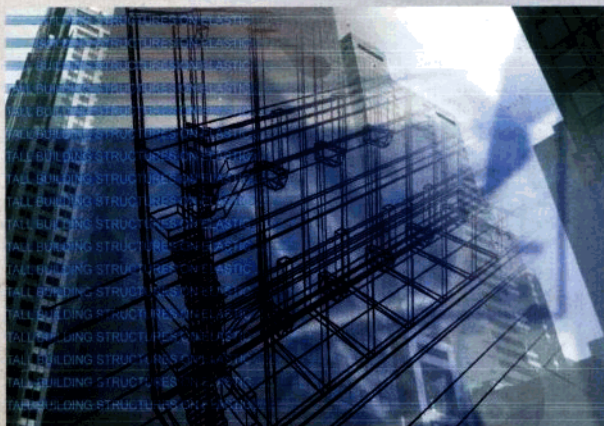
21世纪

宁夏博士学术专著

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弹性地基上高层 建筑结构及半解析法研究

TALL BUILDING STRUCTURES ON ELASTIC SUBGRADE
AND RESEARCH OF SEMI-ANALYTICAL METHOD



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总 序

当今世界,国际综合国力的竞争越来越取决于科技创新能力的竞争。创新是一个民族兴旺发达的决定性因素。创新的关键在人才,人才资源是第一资源。走人才强国之路是到本世纪中叶基本实现社会主义现代化、实现中华民族伟大复兴的战略选择。

高等学校肩负着培养大批各类专业人才的重任,努力为优秀人才脱颖而出创造条件,尤其是下功夫造就一批站在世界科学技术前沿的学术骨干和带头人,以带动和促进民族科技水平与创新能力的提高,是我们义不容辞的任务。

博士研究生教育是我国高等教育的最高层次。培养德智体全面发展、在本学科上掌握坚实宽广的理论和系统深入的专门知识、具有独立从事科学研究的工作能力、在科学理论或专门技术上做出创造性成果的高级专门人才是博士研究生的培养目标。

博士人才虽是当代青年的很小一部分,但却是最

富活力、最富创新能力的高素质尖子人才,与其他杰出人才一样,是建设党政人才、企业经营管理人才、专业技术人才三支队伍的骨干力量,是重点培养党政领导干部、企业家和学科带头人的关键人才。

编审出版本丛书的动机是为博士人才脱颖而出营造良好的学术氛围和社会环境,让他们施展才华,勇于创新;让他们相互交流,相互促进;让他们走向社会,接受选择;让他们再接再厉,永攀高峰。

本丛书涉及自然科学、社会科学、工程技术的各个领域,重点介绍博士人才在各自领域的理论成果和应用成果。其基本特点是:

1.新颖性。本丛书专著有些是在博士学位论文基础上的研究成果,有些是博士新的科研成果,它们能及时反映我区各专业博士在各自学科领域的最新研究成果。

2.创造性。本丛书专著针对各学科领域的专门问题,著者进行了创造性地工作,提出了一些创新性的观点、方法、措施和途径,具有理论意义和实用价值。

3.独立性。本丛书专著是针对各学科某一专门问题进行研究的成果,每本书相互独立,自成体系,适应不同学科的研究生和科研人员参阅。

本学术专著丛书是在宁夏工作的毕业于全国各地院、校的博士回报宁夏人民的一份礼物,愿这份礼物对宁夏相关的教学、科研、产品开发应用以及西部大开发起到积极的推动作用,同时,也希望有更多的博士人才将他们最新的研究成果通过本丛书的形式与大家分享。承蒙著者盛情邀请,特撰数言,以之为序。

陈育宁

二〇〇二年十月于银川

摘 要

本书以常微分方程求解器为工具,用集地基、基础、上部结构为一体的多维半解析分析模型,在弹性范围内对高层建筑结构作了静力与动力分析;对大型桥跨结构在单位移动荷载作用下的影响场也进行了探讨。取得了一些可喜的成果,其中最主要的有以下几个方面:

- ① 利用能量等效原理导出了计算半无限大弹性地基相应于各种变形的等效刚度公式,运用这些公式可以很容易地定量确定出半无限大弹性地基与基础的相互作用,从而为高层建筑结构建立在集地基、基础、上部结构为一体的多维半解析分析模型之上的分析计算奠定了基础。
- ② 用基于常微分方程求解器的半解析分析方法解决了高层建筑结构对多维确定性动力荷载稳态反应的描述与确定。通过算例分析,得出了比较合理的结论:那就是当激励荷载的频率与结构系统的自振频率很接近时,结构系统的反应会出现几百倍大的突变。
- ③ 探索了如何在多维地震荷载作用下,用集地基、基础、上部结构为一体的多维半解析分析模型,对高层建筑结构进行弹性时程分析的原理与方法。这一方法的特点是:将高层建筑结构在多维非确定性地震作用下的弹性时程分析转化成了一系列常微分方程组边值问题的求解,从而使得结构对于多维地震作用的反应可通过解常微分方程组边值问题获得。
- ④ 探讨了如何用基于常微分方程求解器的半解析分析方法来确定大型桥跨结构的影响场,从而为这类结构在移动荷载作用下的分析计算提供了值得应用的工具。通过对某大型悬索桥桥跨

结构中某处的应力影响场及某处的支座反力影响场的确定，得出了令人满意的切合实际的结果。

关键词：高层建筑结构，大型桥跨结构，半解析分析，影响场，结构动力反应，高层结构与地基基础的共同工作

Abstract

The static and dynamic analysis of the structure-foundation-soil interaction system of tall building structures, and the influence field of large bridge structures under moving load were studied and analyzed, Based on multi-dimensional model, in the elastic extent by means of ODE (Ordinary Differential Equation) Solver in the book. The fruitful achievement was obtained. The principal creative works are as follows:

- ❶ The various equivalent stiffness equations of the semi-infinite elastic subgrade, corresponding to the various deformations, were deduced by virtue of energy equivalence principle. By using these equations, the interactions between the subgrade and foundation would be easily determined quantitatively. A semi-analytical approach for the analysis of tall building structures based on the interaction system consisting of the subgrade and the foundation and the super structure was then developed.
- ❷ Using semi-analytical method based on ODE Solver successfully solved the problem of steady-state response for super tall building structures under multi-direction deterministic dynamic loads. A reasonable conclusion was also obtained from the result of a computed example. It is that the response of the structure system would get hundreds times step-increment when the frequency of the excitation load is very close to the natural frequency of the structure system.
- ❸ How to establish the semi-analytical principle and approach of

time history analysis, about tall building structure based on multi-dimensional model of the system consisting of the subgrade and the foundation and the super structure, was researched in elastic extent. The method would convert the time history problem into a succession of ordinary differential equation boundary problems. Then the dynamic responses of tall building structures subjected to multi-direction nondeterministic seismic loads could be computed by ODE Solver.

- ④ A semi-analytical method to calculate the influence fields of large bridge structures based on ODE Solver was formulated. Therefore, the necessary and useful tools were provided for the analysis of bridge structures under moving loads. Some stress and reaction influence fields of a suspension bridge were computed, and some practical and satisfactory results were obtained.

Key words: tall building structures, large bridge structures, semi-analytical analysis, influence fields, structure dynamic-load response, soil-foundation-superstructure interactions of tall-building structures

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第1章

绪 论

为了阐述清楚对弹性地基上高层建筑结构进行半解析分析的理论及工程意义，下面就高层建筑的发展趋势、高层建筑结构的结构特征、高层建筑结构分析方法综述以及本书的研究内容阐述如下。

1.1 高层建筑的发展趋势以及对高层建筑结构进行半解析分析的理论 and 实际意义

21 世纪人类的居住环境会发生多大的变化？再过 50 年最高的摩天大楼会有多高？摩天大楼之间会不会有空中交通？城市中的高架公路、高架铁路会有多少？有多少个城市会拥有地下铁路？大跨度的跨海、跨江大桥会有多少？等等。这些我们都很难说清楚，但有一点是肯定的，那就是：摩天大楼会越建越高，大桥会越修越长，城市中的高架桥、高架路以及地下铁路会越来越多。这也就是说，大型和超大型建筑的发展势不可挡，这是人类社会发展的必然选择。作这种选择的理由主要有两个方面：一是社会生产力与经济的蓬勃发展，经济的发展加快了城市建设的步伐。而高楼大厦和其它一些超大型建筑往往与‘富有’和‘现代’联系在一起，它们不仅是人们拥有财富的物质体现，而且也赋予人们精神上对征服自然和在社会竞争中获得胜利的成功感。由于人类对财富的追求以及对获得成功的欲望都是无止境的，所以人类对建筑物体量不断增大的要求也