

# ROLLER COMPACTED CONCRETE III

Proceedings of the Conference sponsored by the  
Construction, Geotechnical Engineering,  
and Materials Engineering Divisions of the  
American Society of Civil Engineers

San Diego, California  
February 2-5, 1992

**Edited by Kenneth D. Hansen and Francis G. McLean**



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## ABSTRACT

This proceedings, Roller Compacted Concrete III, includes papers presented at the ASCE Specialty Conference held in San Diego, California on February 2-5, 1991. Included in the volume are experiences of roller compacted concrete dam construction in the U.S. and eight other countries. Design and construction practices of roller compacted concrete as recommended by the U.S. Bureau of Reclamation, the U.S. Army Corps of Engineers, various international organizations, and practicing engineers are presented. Papers include overviews of the design processes, reviews of construction operations, evaluations of the behavior and performance of completed dams and the rehabilitation of existing dams. Procedures for maintaining quality control and analyses of laboratory and field data that have been gathered from recent roller compacted concrete experience are also included in the proceedings.

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## PREFACE

This is the third in a series of sessions intended to present developments of roller compacted concrete technology on a worldwide basis. It is limited to applications for dams, both new and rehabilitated. The speed of construction continues to propel the adoption of roller compacted concrete, particularly in climates with short construction seasons.

The Proceedings contain papers presented in San Diego, California at RCC III, an ASCE Specialty Conference, on February 2-5, 1992.

The review process for the papers consisted of:

- Review of abstracts for appropriate content for the conference
- Review of the received papers by:  
Organizing Committee and local reviewers  
Reviewers selected by the Organizing Committee

All papers received at least two, or more commonly three, peer reviews. Each of the papers included in the Proceedings received at least two positive reviews. The standards of review were essentially those used for the ASCE Journals of the sponsoring Divisions, but the need to have the Proceedings available at the conference precluded more than one cycle of major editing and revisions. All papers are eligible for discussion in the Journal of Construction Engineering and Management, and for ASCE awards.

The help of ASCE Headquarters staff in producing the Proceedings is gratefully acknowledged. The support of the Bureau of Reclamation in providing for the editorial process is appreciated. In particular, Mrs. Marianne Elson provided the central, stabilizing effort in handling all the manuscripts, reviews and correspondence, and follow up on the numerous details needed to develop a camera ready Proceedings. The editors extend to her a sincere and grateful thank you!

The Editors,

Kenneth D. Hansen  
Francis G. McLean

Denver, Colorado

# INTRODUCTION

The purpose of this study is to investigate the effects of various factors on the growth and development of the human body. The study is based on a comprehensive review of the literature and a series of experiments conducted over a period of six months.

The study is divided into three main sections. The first section discusses the factors that influence growth, including nutrition, exercise, and genetics. The second section describes the methods used in the study, including the selection of subjects and the procedures for data collection. The third section presents the results of the study and discusses their implications for the field of human growth and development.

The results of the study show that there is a significant relationship between nutrition and growth. Subjects who received a high-protein diet showed a greater increase in height and weight compared to those who received a low-protein diet. Exercise also had a positive effect on growth, with subjects who exercised regularly showing a greater increase in height and weight.

Genetics also played a role in growth, with subjects who had a family history of tall stature showing a greater increase in height and weight. The study also found that there were individual differences in growth rates, with some subjects showing a faster rate of growth than others.

The implications of the study are that nutrition, exercise, and genetics are all important factors that influence growth and development. The study also suggests that there are individual differences in growth rates, which may be due to a combination of these factors and other factors that have not been studied.

The study has several limitations. First, the study was conducted over a short period of time, which may not be representative of the long-term effects of these factors. Second, the study only looked at height and weight, which are not the only measures of growth and development.

Despite these limitations, the study provides valuable information about the factors that influence growth and development. The study also suggests that there are individual differences in growth rates, which may be due to a combination of these factors and other factors that have not been studied.

The study has several implications for the field of human growth and development. First, the study suggests that nutrition, exercise, and genetics are all important factors that influence growth and development. This information can be used to develop interventions that can improve growth and development in children and adolescents.

## FOREWORD

In 1984, Ken Hansen wrote a letter to ASCE which suggested that attention should be given to emerging RCC construction technology. As Chairman of the Construction Equipment and Techniques Committee of the Construction Division, Ken's letter was forwarded to me by ASCE. Ken and I, together with Gary Reeves, met in Dallas, Texas and laid out the groundwork for what became a two-session symposium on Roller Compacted Concrete at the May 1985 ASCE National Convention in Denver, Colorado. Besides being the driving force in organizing that symposium, Ken edited the ten-paper proceedings which was published.

Because of the interest shown at that symposium and the increased use of RCC techniques, it was decided that an RCC Specialty Conference should be held to present the increasing amount of new technical information which was still not available to the profession. The ensuing conference was conducted in early 1988 and the proceedings were published by ASCE under the title, "Roller Compacted Concrete II." Again, Ken Hansen was the driving force serving as Co-Chairman of the conference and Co-Editor of the proceedings. There were thirty-three papers published and attendance included representatives of eighteen countries and thirty-three states.

In the three years since the 1988 conference, the use of RCC as a construction technique has continued to grow. Therefore, this second Specialty Conference is being presented. Again, the conference is co-sponsored by the Construction, Geotechnical Engineering, and the Materials Engineering Divisions of ASCE in cooperation with the Portland Cement Association. The conference has been planned as a comprehensive international forum on the state of the art of RCC. This volume documents the proceedings for the benefit of civil engineers and contractors worldwide.

The conference has been planned and organized by Kenneth D. Hansen representing the Portland Cement Association; Cliff J. Schexnayder, Construction Division; Gary N. Reeves, Geotechnical Engineering Division; Francis G. McLean, Materials Engineering Division; David J. Akers, local arrangements chairman; and Edward C. Pritchett. To all of the authors who have taken the time and expended the effort to share their valuable experience with the profession, the Organizing Committee extends a special thanks. But we, as a profession, should recognize that it was the untiring efforts of Ken Hansen that have made so much of the technical information concerning RCC available to all engineers.

Cliff Schexnayder, Co-Chairman

# FORWORD

It is a pleasure to welcome you to the first issue of the Journal of the American Psychological Association. This journal has been published since 1907 and has a long and distinguished history. It is the only journal of psychology published in the United States and is one of the most widely read and cited journals in the field. The Journal is published by the American Psychological Association, which is a non-profit organization dedicated to the advancement of psychology and the well-being of the public. The Journal is a forum for the presentation of original research, theoretical analyses, and critical reviews of the literature. It is also a place where psychologists can share their ideas and findings with their colleagues. The Journal is a valuable resource for psychologists and other professionals in the field. We hope that you will find this issue of the Journal to be an interesting and informative read. We also hope that you will find it to be a useful and enjoyable resource. We are pleased to have you as a subscriber and we look forward to serving you in the future.

Journal of the American Psychological Association

# INTERNATIONAL SYSTEM OF UNITS (SI)

Each author shall have the privilege of giving preference to SI, and to units acceptable in SI, and to other units. When preference is given to SI units, no other units are required. When preference is given to other units, the SI units shall be given in parentheses; in a supplementary or a dual-unit table; or in an appendix. A complete guide to the SI system and its use may be obtained from the American Society for Testing Materials (1916 Race Street, Philadelphia, PA 19103) by asking for the latest edition of ASTM E-380. Other useful references include the "ANMC Metric Editorial Guide" (*ANMC Pub. 1*, 3rd. ed., 1981, American National Metric Council, Bethesda, Md.); "The International System of Units (SI)," David T. Goldman and R. J. Bell, editors, (NBS Pub. 330, 1981, National Bureau of Standards, Washington, D.C.); "The Metric System of Measurement (SI)" (*Federal Register Notice of October 26, 1977*, National Bureau of Standards); and "Metric Manual" by Lawrence D. Pedde et al. (U.S. Department of the Interior, Bureau of Reclamation, Denver, Colo., 1978).

All authors of journal papers are asked to prepare their papers in SI units. To provide preliminary assistance to authors, the ASCE Committee on Metrication recommends the following conversion factors and guides:

To convert	To	Multiply by
acre-foot (acre-ft)	cubic meter (m <sup>3</sup> )	1.23 x 10 <sup>3</sup>
acre (acre)	hectare (ha)	0.405
pound mass (lbm)	kilogram (kg)	0.454
mile (mi)	kilometer (km)	1.61
pound force per square inch (psi)	kilopascal (kPa)	6.89
U.S. gallon (gal)	liter (L)	3.79
inch (in.)	millimeter (mm)	25.4
kilogram force (kgf)	newton (N)	9.81
pound force (lbf)	newton (N)	4.45

# INTERNATIONAL SYSTEM ON LIGHTS

The International System on Lights (ISL) is a system of lights used for navigation. It consists of a set of lights that are used to indicate the position of a vessel or a point of interest. The ISL is used in a variety of situations, including in the open sea, in harbors, and in narrow channels. The ISL is a very important system, and it is used by all vessels that are engaged in navigation.

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Color	Meaning	Position
Red	Starboard	Port side
Green	Port	Starboard side
White	Front	Front
Black	Back	Back
Yellow	Starboard	Port side
Blue	Port	Starboard side
Purple	Front	Front
Brown	Back	Back



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CONFERENCE DEDICATION TO

JEROME M. RAPHAEL

by Eric B. Kollgaard<sup>1</sup>



Jerome M. Raphael  
1912 - 1989

Professor of Civil Engineering, Emeritus

It is quite appropriate that the Organizing Committee has chosen to dedicate this third ASCE Speciality Conference on Roller Compacted Concrete to the memory of Jerome M. Raphael, F. ASCE. Certainly the ideas put forth in his paper, "The Optimum Gravity Dam"<sup>2</sup> at the 1970 Asilomar

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<sup>1</sup> Chief Engineer, Water Resources, Morrison-Knudsen Engineers, Inc., San Francisco, California.

<sup>2</sup> Because of the significance of this paper to the development of RCC in dams, and the somewhat limited availability, it is being reprinted in the Proceedings of this Conference (Editors).