

《岩土工程学报》

第7卷 总目录

1985年第1~6期(总24~29)

第7卷 第1期(总24) 1985年1月

- 正常压密饱和粘土的抗剪强度理论 魏汝龙(1)
- 拱坝坝肩稳定的地质力学整体模型试验研究 陈国荣、吴中如、曹明、沈洪俊(15)
- 确定岩石动、静力剪切强度的方法 吴绵拔(25)
- 地表面最大加速度的推算式 竺存宏(37)

短 文

- 湿陷性黄土间歇浸水试验 刘明振(47)
- 利用二氧化碳和施加反压饱和砂样的液化试验 王华山、阎明礼(55)
- 渤海海底重塑土的强度性质 杜金声(61)
- 软土的地震波速与标准贯入击数、深度的相关特征 郑金安(68)

专题综述

- 三轴试验中橡皮膜顺变性对体积变化和孔隙水压力的影响 王洪瑾(76)
- 挪威在离岸工程土工问题方面的理论与实践 张诚厚(85)

资 料

- 国际制单位及其换算 (99)

第7卷 第2期(总25) 1985年3月

- 地下岩洞动力计算的一种工程近似解法 曹志远、张耀勤(1)
- 岩体工程有限元分析中弱面的力学模型——弱面单元分析 陶纪南(13)
- 单桩弯曲自振频率与地基侧向基床系数 沈任工(25)
- 扶壁码头刚性模型土压力量测 魏元友(35)
- 膨胀岩特性研究及其在工程中的应用 孙学毅(46)
- 一种土层原地应变(力)测量方法及其实验与现场应用 孙寿成、张绍治(56)
- 压缩状态下岩石的I、II复合型断裂试验 夏照伦、黎继珍、罗忠庆、于惠珍(66)
- 土坝坝体水分分布状态的数学模型和计算方法 黄俊、孙玉生(75)

短 文

- 确定岩石强度包络线的新方法——单块法 吴玉山、李纪鼎(85)
- 普遍应力状态下的内弹性非线性K-G模型 夏洪(92)

岩土工程标准

- 协调、统一、加速开展岩土工程标准化工作 樊宜、张一新(102)

资 料

岩土工程与岩土力学常用物理量的符号、单位和名词术语一览表 (107)

第7卷 第3期(总26) 1985年5月

大型箱基变形计算 黎文芳、董奇石(1)
 岩石圆盘劈裂刚性试验研究 蔡跃军、刘宝琛、崔志莲(9)
 随机波浪荷载下海底地基的统一等效谐振荷载 何广讷、曹亚林(16)
 多层地基横向荷载桩试验资料分析方法 周 铭、王惠初、鲁子爱(25)

短 文

计算推力桩的双参数法以及过桩参数的确定 吴恒立(41)
 无粘性土坝坡稳定分析 王鸿兴(47)
 饱和软粘土中单桩承载力随时间的增长 胡中雄(58)
 孔隙压力系数与饱和度的关系 姜 炎(62)
 地下圆形隧洞回填效应的探讨 宋熙太(68)
 膨胀土地基建筑物的变形特征 曹可之(78)

岩土工程标准化

我国细粒土在塑性图上的分布特征 李生林、王正宏(84)
 界限含水量的试验现状和展望 周序源、张剑峰(90)

第7卷 第4期(总27) 1985年7月

油罐软粘土地基性状 龚晓南、曾国熙(1)
 采用碎石桩加固龙口电厂地基 李宏琇(12)
 砂浆锚杆和喷射混凝土支护的受力分析 张德兴(24)
 砾石排水桩与地面压重的抗液化效果 顾卫华、王余庆(34)
 两个典型场地的液化和动力反应分析 符圣聪、江静贝(45)
 嵌岩钻孔桩横向受力试桩的分析 胡玉山(54)

短 文

角度偏差对钻孔变形计测量结果的影响 李锡润(64)
 三轴固结不排水试验数据的自动采集和处理 魏汝龙、宋永祥、李大梁、周云娟(69)
 泰安地面塌陷成因的探讨 陶克靖(77)

岩土工程标准

液限、塑限标准的选定 周鸿逵、蒋淑青、张焯英(86)
 粘性土室内击实标准探讨 陶秀珍(94)

第7卷 第5期(总28) 1985年9月

粉煤灰的动剪切模量 曾国熙、顾尧章、吴建平(1)
 中国红土的微结构和工程性质 高国瑞(10)

钻孔灌注桩的荷载传递性能	洪毓康、陈强华 (22)
不完整井渗流的近似计算	沙金焯 (36)
饱和粘性土地基不排水沉降的变化规律	徐少曼 (49)
鲁布格水电站引水隧洞围岩变形分析	陈相震、汪志民 (59)

综 述

原位十字板剪切试验	盛崇文 (66)
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短 文

断桩锤击动测判别法	尹永年、杨位洗、余绍襄、梁臻彬 (74)
岩石湿度对纵波速度的影响	罗淦堂、胡月兰 (80)

第7卷 第6期(总29) 1985年11月

岩石超声波波谱特性、力学特性及其相关性研究	蔡忠理、刘 克、黄迹英 (1)
箱形框架与弹簧地基共同作用的实用计算	王维英 (7)
土壤动压缩模量的共振柱法测定	石兆吉、丰万玲、张占吉 (25)
非饱和和无粘性土的动剪切模量	吴世明 (34)
风化土料修建高坝的可能性	杨天林 (43)
含泥砂砾石的强度特性	张克昌、汪友平 (52)

短 文

扩底墩地基土的位移和应力	
——弹性力学有限单元法的应用	周 红 (61)
加筋乳胶膜在振动单剪试验中的应用	左元明 (71)

讨 论

关于混凝土坝基岩抗滑稳定的指标选择	
——兼与潘家铮同志商榷	叶金汉 (75)
对叶金汉同志讨论文的答复	潘家铮 (79)

Contents of Vol. 7, No. 1—6 in 1985 (Total No. 24—29)**Vol. 7, No. 1 (Total 24), Jan., 1985**

Theory of Shear Strength for Normally Consolidated Saturated Clay	Wei Ru-long (1)
An Investigation on Stability of a Gravity-arch Dam and Its Abutments by Geomechanical Model Test	Chen Guo-qi, Wu Zhong-ru, Cao Ming and Shen Hong-jun (15)
Methods of Determining Shear Strength of Rocks at Dynamic or Static Loading	Wu Miao-ba (25)
A Formula for Determination of Maximum Acceleration of Ground	

..... *Zhu Cun-hong* (37)

NOTES

- Intermittently Wetted Experiment of the Collapsible Loess
 *Liu Ming-Zhen* (47)
- Triaxial Liquifaction Test by Using Carbon Dioxide and Back Pressure
 to Saturate Sand Specimen..... *Wang Hua-shan and Yan Ming-li* (55)
- Strength Characteristics of Bohai Remolded Seabed Soils
 *Du Jin-sheng* (61)
- The Relationship of Seismic Wave Velocity with Blow Number of SPT
 and Depth in Soft Soil..... *Zhang Jin-an* (68)

REVIEW

- Survey on the Effect of Membrane Compliance upon Volume Change
 and Pore Pressure in Triaxial Tests..... *Wang Hong-jin* (76)
- Theory and Practice of Geotechnical Problems in Offshore Engineering
 of Norwegian..... *Zhang Cheng-hou* (85)

INFORMATION

- SI Basis Units and Their Conversion Factors for Use in Geotechnics... (99)

Vol. 7, No. 2, (Total 25), Mar., 1985

- An Engineering Approximate Method for Dynamic Calculation of Under-
 ground Rock Cavity *Cao Zhi-yuan and Zhang Yao-qin* (1)
- The Mechanical Model for the Weak Plane with Finite Element Ana-
 lysis in Rock Mass Engineering—Element Analysis of the Weak
 Plane..... *Tao Ji-nan* (13)
- The Frequency Spectra at Lateral Bending Free Vibration of the Pile
 and the Modulus of Subgrade..... *Shen Ren-gong* (25)
- Measurements of Earth Pressure Acting on Counterfort Structure Wharf
 Model (Rigid Body)..... *Wei Yuan-you* (35)
- Research on Expansive Rock Properties and Its Application to Engi-
 neering..... *Sun Xue-yi* (46)
- A Method of Determination the Principle Strain Axis of Soil layer in
 Situ and Its Experiments and Application
 *Sun Shou-cheng and Zhang Shao-zhi* (56)
- Mixed Mode (I, II) Fracture Test of Rock Subjected to Compressive
 Loading..... *Xia Xi-lun, Li Ji-zhen, Luo Zong-ging and Yu Hui-zhen* (66)
- A Mathematical Model and A Numerical Calculation Method for the

Distribution State of Moisture Content in Earth Dams	<i>Huang Jun and Sun Yu-sheng</i> (75)
---	--

NOTES

Single Specimen Test—A New Approach to Envelope of Strength for Rock	<i>Wu Yu-shan and Li Ji-ding</i> (85)
“Naylor” Nonlinear-Elastic Model for Soils in Space Stress State	<i>Xia Hong</i> (92)

GEOTECHNICAL STANDARDIZATION

Unity, Coordination and Speeding-up of Geotechnical Standardization	<i>Dou Yi and Zhang Yi-xin</i> (102)
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INFORMATION

List of Symbols, Units and Terms for the Commonly Used Physical Quantities in Geotechnical Engineering and Geomechanics.....	(107)
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Vol. 7, No. 3 (Total 26) May, 1985

The Deformation Calculation of a Large Box Foundation	<i>Li Wen-fang and Dong Qi-shi</i> (1)
Splitting Test for Marble Disc	<i>Cai Yue-jun, Liu Bao-chen and Cui Zhi-lian</i> (9)
Unified Equivalent Harmonic Loading on Seabed Soil Foundation for Random Ocean Wave Loading.....	<i>He Guang-na and Cao Ya-lin</i> (16)
The Analytical Method for the Experimental Data of the Laterally Loaded Piles in Multiple Layers of Soil	<i>Zhou Ming, Wang Hui-chu and Lu Zi-ai</i> (25)

NOTES

Calculation of Lateral Loaded Pile by Double-Parameter Method and Determination of the Parameters in the Case of Long Pile	<i>Wu Heng-li</i> (41)
Slope Stability Analysis of Nonclay Earth Dam.....	<i>Wang Hong-xing</i> (47)
The Increase of Loading Capacity of Single Pile With Time in Saturatid Clay.....	<i>Hu Zhong-xuon</i> (58)
The Relation between Pore Pressure Parameter and Degree of Saturation	<i>Lou Yan</i> (62)
Study Backpacking Effect in Underground Circular Chamber	

-*Song Xi-tai* (68)
 The Deformation Characteristic of Some Building on Expansive Soil
 Ground.....*Cao Ke-zhi* (78)

GEOTECHNICAL STANDARDIZATION

- Distribution Character of Fine-grained Soil in China on the Plasticity
 Chart.....*Li Sheng-lin and Wang Zheng-hong* (84)
 The Current Situation and Prospect of the Tests of Atterberg Limits
*Zhou Xu-yuan and Zhang Jian-feng* (90)

Vol. 7, No. 4 (Total 27) July, 1985

- Behaviour of the Soft Clay Ground under Tank
*Gong Xiao-nan and Zeng Guo-xi* (1)
 Ground Improvement of Longkou Power Plant by Stone Columns
 *Li Hong-Xiu* (12)
 The Mechanical Analysis to Rock Bolts and Shotcrete Lining
*Zhang De-xing* (24)
 The Liquefaction-inhibiting Effect of Gravel Drains and Surface Load
*Gu Wei-hua and Wang Yu-qing* (34)
 Liquefaction and Dynamic Response Analysis at Two Typical Sites
*Fu Sheng-cong and Jiang Jing-bei* (45)
 The Analysis of Laterally Loaded Socketed Piles.....*Hu Yu-shan* (54)

NOTES

- The Influence of Inclination on Measurement of Borehole Deformation
 Gage.....*Li Xi-run* (64)
 Data Acquisition and Processing for the Consolidated-undrained Triaxial
 Test.....
*Wei Ru-long, Song Yong-xiang, Li Da-liang and Zhou Yun-juan* (69)
 Study of the Cause for Ground Subsiding of Taian
*Tao Ke-jing* (77)

GEOTECHNICAL STANDARDIZATION

- Selection of the Standard for Liquid Limit and Plastic Limit
*Zhou Hong-kui, Jiang Shu-qing and Zhang Chao-ying* (86)
 Study on Standard of the Laboratory Compaction Test for Cohesive
 Soil.....*Tao xiu-zhen* (94)

Vol. 7, No. 5, (Total 28), Sept., 1985

- Dynamic Shear Moduli of Flyashes
*Zhen Guo-xi, Gu Yao-Zhang, Wu Jian-ping* (1)
- The Microstructures and Engineering Properties of Red Soil in China
*Gao Guo-rui* (10)
- Load Transfer Behaviour of Bored Piles
*Hong Yu-kang and Chen Qiang-hua* (22)
- The Approximate Calculation of Partially Penetrating well
 *Sha Jin-xuan* (36)
- Regularity of Variation for Undrained Settlement of Saturated Cohesive
 Subsoils.....*Xu Shao-man* (49)
- Deformation Analysis of Surrounding Rock on Diversion Tunnel in
 Lubuge Hydraulic Power Station
*Chen Xiang-zhen and Wang Zhi-ming* (59)

REVIEW

- Review of In-situ Vane Shear Test.....*Sheng Chong-wen* (66)

NOTES

- Cracked Pile Detection by Hammer-blow Dynamic Method
*Yin Yong-nian, Yang Wei-guang, Yu Shao-xiang and Liang Liu-bin* (74)
- The Influence of Moisture of Rock on the Longitudinal Wave Velocity
*Luo Gan-tana and Hu Yue-lan* (80)

Vol. 7, No. 6, (Total 29). Nov., 1985

- The Study of Relation between Ultrasonic Waves Frequency Spectral
 Properties and Mechanical Properties of Rock
*Chai Zhong-li, Liu Ke and Huang Ji-ying* (1)
- An Applied Compute Method for Mutual Action of Box Frame and
 Spring Foundation..... *Wang Wei-ying* (7)
- The Measurement of Dynamic Young's Modulus by Resonant Column
 Method.....*Shi Zhao-ji, Feng Wan-ling and Zhang Zhan-ji* (25)
- Dynamic Shear Modulus of Partly Saturated Cohesionless Soils
*Wu Shi-ming* (34)
- Possibility of Using Weathered Materials to Construct High Dams
 *Yang Tian-lin* (43)
- Strength Characteristics of Sand-Gravel With Fine-Grained Soil

.....*Zhaq Ke-chang and Wang You-ping* (52)

NOTES

Displacements and Stresses in the Soil of Belled Piers Foundation——

An Application of Finit Element Method of Elastic Theory

.....*Zhou Hong* (61)

The Application of Reinforced Rubber Membrane in Cylic Simple Shear

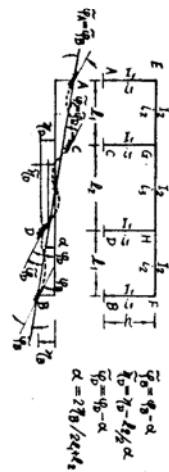
Test.....*Zuo Yuan-ming* (71)

DISCUSSION

Slection of Shear Strength Index of Rock in Compating the Stability

of Dam Foundation.....*Ye Jin-han* (75)

Closure..... *Pan Jia-zheng* (79)



图例

柱脚位移计算公式

$$\begin{pmatrix} \tilde{\varphi}_B \\ \tilde{\varphi}_D \\ \tilde{\varphi}_D \end{pmatrix} = \begin{pmatrix} \frac{1}{cbK_0} & & \\ & \frac{1}{bK_0} & \\ & & \frac{1}{cbK_0} \end{pmatrix} \begin{pmatrix} -2.9165 & 6.2999 & -5.8331 & 2.1642 \\ -\tilde{F}'_{D,1} & -\tilde{F}'_{D,2} & -\tilde{F}'_{D,3} & -(\tilde{F}'_{D,4} - \frac{l_2}{7c}) \\ (-0.7668) & (-0.5751) & (0.0349) & (-0.3311) \\ (-1.8858) & (1.3029) & (-0.0041) & (-0.2860) \end{pmatrix} \begin{pmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{pmatrix}$$

注：括弧中数字为等跨时值

柱脚反力

Q_B	$-\frac{3h}{l_1} \frac{i_1(2i_1+13i_2+3i_3)+6i_2(i_1+2i_2)}{A}$	$\frac{3}{h} \frac{i_1(i_1+6i_2+6i_3)}{A}$	$-\frac{3}{h} \frac{i_1(i_1+6i_2)}{A}$	Q_B^c
N_B	$-\frac{3h}{l_1} \frac{i_1(4i_1+2i_2+3i_3)}{A}$	$\frac{12}{l_1} \frac{i_2(2i_1+i_2+3i_3)}{A}$	$\frac{12}{l_1} \frac{i_2(2i_1+i_2)}{A}$	N_B^c
M_B	$-\frac{h}{l_1} \frac{i_1(2i_1+7i_2+3i_3)+3i_2(i_1+2i_2)}{A}$	$\frac{i_1(5i_2+3i_3-i_1)}{A}$	$\frac{i_1(3i_1+7i_2)}{A}$	M_B^c
Q_D	$-\frac{i_1(2i_1+13i_2+12i_3)+6i_2(i_1+2i_2)}{A}$	$-\frac{3}{h} \frac{i_1(i_1+6i_2+6i_3)}{A}$	$-\frac{3}{h} \frac{i_1(i_1+6i_2)}{A}$	Q_D^c
N_D	$-\frac{3h}{l_1} \frac{i_1(4i_1+2i_2+3i_3)+i_2(4i_1+2i_2)l_1/l_2}{A}$	$-\frac{6}{l_1} \frac{i_2(4i_1-3i_2)l_1/l_2+2i_2(2i_1+i_2+3i_3)}{A}$	$\frac{6}{l_1} \frac{i_2(5i_1+8i_2)l_1/l_2-2i_2(2i_1+i_2)}{A}$	N_D^c
M_D	$-\frac{h}{l_1} \frac{i_1(2i_1+7i_2+6i_3)+3i_2(i_1+2i_2)}{A}$	$-\frac{i_1(3i_1+7i_2+9i_3)}{A}$	$\frac{i_1(5i_2-i_1)}{A}$	M_D^c

{R}

Q_B	$-\frac{6EI_1}{h^2} \frac{i_1(i_1+7i_2+6i_3)+6i_2(i_1+2i_2)}{A}$	$\frac{36EI_1}{h^2 l_1} \frac{i_2(i_1+6i_2)l_1/l_2+3i_2 i_3}{A}$	$-\frac{6EI_1}{h^2} \frac{i_1(i_1+7i_2+3i_3)+6i_2(i_1+2i_2)}{A}$
N_B	$\frac{6EI_2}{l_1^2} \frac{i_1(4i_1+2i_2-3i_3)}{A}$	$-\frac{72EI_2}{l_1^3} \left(\frac{1}{6} + \frac{i_2(6i_1+14i_2)l_1/l_2+(4i_1+2i_2+3i_3)}{A} \right)$	$\frac{6EI_2}{l_1^2} \frac{i_1(4i_1+2i_2+9i_3)}{A}$
M_B	$\frac{2EI_1}{h} \frac{i_1(3i_1+28i_2+18i_3)+15i_2(i_1+2i_2)}{A}$	$\frac{6EI_1}{h l_1} \frac{i_2(6i_1+14i_2)l_1/l_2-i_2(2i_1+4i_1-3i_3)}{A}$	$-\frac{2EI_1}{h} \frac{i_1(3i_1+14i_2+9i_3)+6i_2(i_1+2i_2)}{A}$
Q_D	$-\frac{6EI_1}{h^2} \frac{i_1(i_1+7i_2+6i_3)+6i_2(i_1+2i_2)}{A}$	$-\frac{36EI_1}{h^2 l_1} \frac{i_2(i_1+6i_2)l_1/l_2+3i_2 i_3}{A}$	$-\frac{6EI_1}{h^2} \frac{i_1(i_1+7i_2+3i_3)+6i_2(i_1+2i_2)}{A}$
N_D	$\frac{6EI_2}{l_1^2} \frac{i_1(4i_1+2i_2-3i_3)}{A}$	$-\frac{72EI_2}{l_1^3} \left(\frac{1}{6} + \frac{i_2(6i_1+14i_2)l_1/l_2+(4i_1+2i_2+3i_3)}{A} \right)$	$\frac{6EI_2}{l_1^2} \frac{i_1(4i_1+2i_2+9i_3)}{A}$
M_D	$\frac{2EI_1}{h} \frac{i_1(3i_1+28i_2+18i_3)+15i_2(i_1+2i_2)}{A}$	$\frac{6EI_1}{h l_1} \frac{i_2(6i_1+14i_2)l_1/l_2-i_2(2i_1+4i_1-3i_3)}{A}$	$-\frac{2EI_1}{h} \frac{i_1(3i_1+14i_2+9i_3)+6i_2(i_1+2i_2)}{A}$

地基反力 {P} 算式

$\begin{pmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{pmatrix} = \begin{pmatrix} S_{P,1,1}^c \\ S_{P,2,2}^c \\ S_{P,3,3}^c \\ -M_{P,1}^c/c \end{pmatrix}$	$\begin{pmatrix} -2.2500\gamma - 2.9165\psi_1 + \tilde{F}'_{D,1}\Omega_1 + \tilde{F}'_{D,1}\Omega_2 + 42.050 \\ 0.7000\gamma + 6.2999\psi_1 + \tilde{F}'_{D,2}\Omega_1 + \tilde{F}'_{D,2}\Omega_2 - 22.139 \\ 0.0333\gamma - 5.8331\psi_1 + \tilde{F}'_{D,3}\Omega_1 + \tilde{F}'_{D,3}\Omega_2 + 38.091 \\ -0.0024\gamma + 2.1642\psi_1 + \tilde{F}'_{D,4}\Omega_1 + \tilde{F}'_{D,4}\Omega_2 + 8.405 \\ 2.5005\gamma - 2.9165\psi_2 + \tilde{F}'_{D,1}\Omega_2 + 69.128 \\ -2.1166\gamma + 6.2999\psi_2 + \tilde{F}'_{D,2}\Omega_2 + \tilde{F}'_{D,2}\Omega_3 - 15.982 \\ 0.7500\gamma - 5.8331\psi_2 + \tilde{F}'_{D,3}\Omega_2 + \tilde{F}'_{D,3}\Omega_3 + 18.779 \\ 0.0143\gamma + 2.1642\psi_2 + \tilde{F}'_{D,4}\Omega_2 + \tilde{F}'_{D,4}\Omega_3 + 4.984 \\ -4.1631\gamma - 2.9165\psi_3 + \tilde{F}'_{D,1}\Omega_3 + 68.461 \\ 3.7509\gamma + 6.2999\psi_3 + \tilde{F}'_{D,2}\Omega_3 + \tilde{F}'_{D,2}\Omega_4 + 25.923 \\ -2.6505\gamma - 5.8331\psi_3 + \tilde{F}'_{D,3}\Omega_3 + \tilde{F}'_{D,3}\Omega_4 + 5.632 \\ 0.8810\gamma + 2.1642\psi_3 + \tilde{F}'_{D,4}\Omega_3 + \tilde{F}'_{D,4}\Omega_4 + 1.516 \end{pmatrix}^T$
$\psi_1 = \frac{-32c^2 \bar{N}_B \varphi_B + 12 \bar{M}_B \varphi_B}{c^3 b K_0}$	$\psi_2 = \frac{-20c \bar{N}_B \varphi_B + 12 \bar{M}_B \varphi_B}{c^3 b K_0}$
$\psi_3 = \frac{-8c \bar{N}_B \varphi_B + 12 \bar{M}_B \varphi_B}{c^3 b K_0}$	$\psi_4 = \frac{-20c \bar{N}_B \varphi_D - 12 \bar{M}_B \varphi_D}{c^3 b K_0}$
$\psi_5 = \frac{8c \bar{N}_B \varphi_D - 12 \bar{M}_B \varphi_D}{c^3 b K_0}$	$\psi_6 = \frac{8c \bar{N}_B \varphi_D - 12 \bar{M}_B \varphi_D}{c^3 b K_0}$
$\Omega_1 = \frac{-32c^2 \bar{N}_B \varphi_D + 12 \bar{M}_B \varphi_D}{c^3 b K_0}$	$\Omega_2 = \frac{-8c \bar{N}_B \varphi_D + 12 \bar{M}_B \varphi_D}{c^3 b K_0}$
$\Omega_3 = \frac{-20c \bar{N}_B \varphi_D + 12 \bar{M}_B \varphi_D}{c^3 b K_0}$	$\Omega_4 = \frac{-8c \bar{N}_B \varphi_D + 12 \bar{M}_B \varphi_D}{c^3 b K_0}$

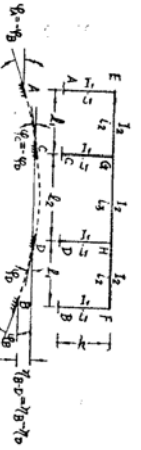


图 例

$$\begin{pmatrix} -\eta_{B-C} \\ \varphi_B \\ \varphi_D \end{pmatrix} = \begin{pmatrix} \frac{1}{bK_0} \begin{pmatrix} F_{D_1,1} \\ (0.3286) \end{pmatrix} & F_{D_2,2} & F_{D_3,3} & F_{D_4,4} \\ \frac{1}{cbK_0} \begin{pmatrix} -2.9165 \\ (-1.0898) \end{pmatrix} & 6.2999 & -5.8331 & 2.4499 \\ \frac{1}{cbK_0} \begin{pmatrix} F'_{D_1,1} \\ (1.0414) \end{pmatrix} & F'_{D_2,2} & F'_{D_3,3} & F'_{D_4,4} \end{pmatrix} \begin{pmatrix} P_1 \\ P_2 \\ P_3 \\ P_4 \end{pmatrix}$$

注：括弧中数字为等跨时值

地基反力 $\{P_i\}$ 算式

$$\begin{pmatrix} -0.2500\gamma - F_{D_1,1}\varphi_1 - 2.9165\psi_1 + F'_{D_1,1}\Omega_1 + 6.177 \\ 0.1000\gamma - F_{D_2,2}\varphi_2 + 6.2999\psi_2 + F'_{D_2,2}\Omega_2 - 5.701 \\ 0.1667\gamma - F_{D_3,3}\varphi_3 - 5.8331\psi_3 + F'_{D_3,3}\Omega_3 + 35.173 \\ -0.0167\gamma - (1-F_{D_4,4})\varphi_4 + 2.4499\psi_4 + F'_{D_4,4}\Omega_4 + 8.929 \\ 0.8333\gamma - F_{D_1,1}\varphi_2 - 2.9165\psi_2 + F'_{D_1,1}\Omega_2 - 4.848 \\ -1.4501\gamma - F_{D_2,2}\varphi_2 + 6.2999\psi_2 + F'_{D_2,2}\Omega_2 + 1.819 \\ 0.5803\gamma - F_{D_3,3}\varphi_2 - 5.8331\psi_2 + F'_{D_3,3}\Omega_2 + 15.500 \\ 0.0334\gamma - (1-F_{D_4,4})\varphi_2 + 2.4499\psi_2 + F'_{D_4,4}\Omega_2 + 5.085 \\ -0.8334\gamma - F_{D_1,1}\varphi_3 - 2.9165\psi_3 + F'_{D_1,1}\Omega_3 - 50.848 \\ 2.2495\gamma - F_{D_2,2}\varphi_3 + 6.2999\psi_3 + F'_{D_2,2}\Omega_3 + 51.448 \\ -2.2882\gamma - F_{D_3,3}\varphi_3 - 5.8331\psi_3 + F'_{D_3,3}\Omega_3 + 0.613 \\ 0.8333\gamma - (1-F_{D_4,4})\varphi_3 + 2.4499\psi_3 + F'_{D_4,4}\Omega_3 + 2.067 \end{pmatrix}^T = \begin{pmatrix} P_1 \\ P_2 \\ P_3 \\ P_4 \end{pmatrix} \begin{pmatrix} S_{P_1,1}^P \\ S_{P_2,2}^P \\ S_{P_3,3}^P \\ S_{P_4,4}^P \end{pmatrix} + \begin{pmatrix} Q_{D^C} \\ N_{D^C} \\ M_{D^C} \end{pmatrix}$$

柱脚反力 $\{R_i\}$ 算式

$$\begin{pmatrix} Q_B \\ N_B \\ M_B \\ Q_D \\ N_D \\ M_D \end{pmatrix} = \begin{pmatrix} \frac{1}{h} \frac{3i(2i_1+2i_2+i_3)}{A} & -\frac{1}{h} \frac{3i i_2}{A} \\ \frac{1}{l_1} \frac{3i_2(2i_1+i_2+i_3)}{A} & \frac{1}{l_1} \frac{3i_2(2i_1+i_2)}{A} \\ \frac{-1}{h} \frac{3i i_2}{A} & \frac{1}{h} \frac{6i_1(i_1+i_2)}{A} \\ \frac{-1}{l_1} \frac{3i_2(2i_1+i_2+i_3)}{A} & \frac{-1}{l_1} \frac{3i_2(2i_1+i_2)}{A} \\ \frac{-i i_2}{A} & -\frac{i i_2}{A} \\ \frac{-1}{h} \frac{3i i_2}{A} & \frac{-1}{h} \frac{6i_1(i_1+i_2)}{A} \end{pmatrix} \begin{pmatrix} Q_{B^C} \\ N_{B^C} \\ M_{B^C} \\ Q_{D^C} \\ N_{D^C} \\ M_{D^C} \end{pmatrix} + \begin{pmatrix} -\sum M_{R^C} \\ -\sum M_{H^C} \end{pmatrix}$$

$$\begin{pmatrix} -18EI_1 \frac{1}{h^2 l_1} \frac{i_2(2i_1+i_2+i_3)}{A} & \frac{6EI_1}{h^2} \frac{i_1(2i_1+i_2+i_3) + i_2(3i_2+2i_1)}{A} \\ \frac{6EI_1}{l_1^3} \frac{4i_1(2i_1+i_2) + i_2(4i_1+i_2)}{A} & \frac{-6EI_1}{l_1^2} \frac{i_1(2i_1+i_2+i_3)}{A} \\ -\frac{6EI_1}{h l_1} \frac{i_2(2i_1+i_2+i_3)}{A} & \frac{2EI_1}{h} \frac{i_1(6i_1+14i_2+3i_3) + 2i_2(3i_2+2i_1)}{A} \\ \frac{-18EI_1}{h^2 l_1} \frac{i_2(2i_1+i_2)}{A} & \frac{6EI_1}{h^2} \frac{i i_2}{A} \\ \frac{-6EI_1}{l_1^3} \frac{4i_1(2i_1+i_2) + i_2(4i_1+i_2)}{A} & \frac{6EI_1}{l_1^2} \frac{i_1(2i_1+i_2+i_3)}{A} \\ \frac{-6EI_1}{h l_1} \frac{i_2(2i_1+i_2)}{A} & \frac{2EI_1}{h} \frac{i i_2}{A} \end{pmatrix} \begin{pmatrix} \varphi_B \\ \varphi_B \\ \varphi_D \\ \varphi_B \\ \varphi_B \\ \varphi_D \end{pmatrix}$$

$A = 2(2i_1+2i_2+i_3)(i_1+i_2) - i_2^2$

$$\varphi_1 = \frac{[12c^2 l_1 - (3c-l_2)^2] \sqrt{N_{B_1} \eta_B} - 12c^2 \bar{M}_{B_1} \eta_B - 12[c^2 - \frac{(3c-l_2)^2}{4}] \bar{M}_{D_1} \eta_B}{c^3 b K_0}$$

$$\varphi_2 = \frac{20c \sqrt{N_{B_1} \eta_B} - 12 \bar{M}_{B_1} \eta_B}{c^3 b K_0}$$

$$\varphi_3 = \frac{8c \sqrt{N_{B_1} \eta_B} - 12 \bar{M}_{B_1} \eta_B}{c^3 b K_0}$$

$$\psi_1 = \frac{-[12c^2 l_1 - (3c-l_2)^2] \sqrt{N_{B_1} \varphi_B} + 12c^2 \bar{M}_{B_1} \varphi_B + 12[c^2 - \frac{(3c-l_2)^2}{4}] \bar{M}_{D_1} \varphi_D}{c^3 b K_0}$$

$$\psi_2 = \frac{-20c \sqrt{N_{B_1} \varphi_B} + 12 \bar{M}_{B_1} \varphi_B}{c^3 b K_0}$$

$$\psi_3 = \frac{-8c \sqrt{N_{B_1} \varphi_B} + 12 \bar{M}_{B_1} \varphi_B}{c^3 b K_0}$$

$$\Omega_1 = \frac{-[12c^2 l_1 - (3c-l_2)^2] \sqrt{N_{B_1} \varphi_D} + 12c^2 \bar{M}_{B_1} \varphi_D + 12[c^2 - \frac{(3c-l_2)^2}{4}] \bar{M}_{D_1} \varphi_D}{c^3 b K_0}$$

$$\Omega_2 = \frac{-20c \sqrt{N_{B_1} \varphi_D} + 12 \bar{M}_{B_1} \varphi_D}{c^3 b K_0}$$

$$\Omega_3 = \frac{-8c \sqrt{N_{B_1} \varphi_D} + 12 \bar{M}_{B_1} \varphi_D}{c^3 b K_0}$$

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Vol. 7, No.6 (Total 29), Nov., 1985.

CONTENTS

- The Study of Relation between Ultrasonic Waves Frequency Spectral Properties and Mechanical Properties of Rock
.....*Chai Zhong-li, Liu Ke and Huang Ji-ying* (1)
- An Applied Compute Method for Mutual Action of Box Frame and Spring Foundation.....*Wang Wei-ying* (7)
- The Measurement of Dynamic Young's Modulus by Resonant Column Method.....*Shi Zhao-ji, Feng Wan-ling and Zhang Zhan-ji* (25)
- Dynamic Shear Modulus of Partly Saturated Cohesionless Soils
.....*Wu Shi-ming* (34)
- Possibility of Using Weathered Materials to Construct High Dams
.....*Yang Tian-lin* (43)
- Strength Characteristics of Sand-Gravel With Fine-Grained Soil
..... *Zhag Ke-chang and Wang You-ping* (52)

NOTES

- Displacements and Stresses in the Soil of Belled Piers Foundation
An Application of Finit Element Method of Elastic Theory
.....*Zhou Hong* (61)
- The Application of Reinforced Rubber Membrane in Cyclic Simple Shear Test.....*Zuo Yuan-ming* (71)

DISCUSSION

- Slection of Shear Strength Index of Rock in Compating the Stability of Dam Foundation.....*Ye Jin-han* (75)
- Closure*Pan Jia-zheng* (79)
- Contents of Vol. 7 (82)

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