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G.P. Tschebotarioff Address

Technical Committee 207 ISSMGE "Soil-Structure Interaction and Retaining Walls", of which I have been honoured to be the Chairman since 2005, has organized eight conferences and special sessions in Saint Petersburg, Ghent, Moscow, Rostock, Dubrovnik and Paris.

This conference which is taking place during the white nights in Saint Petersburg is dedicated to the memory of an outstanding geotechnical expert Gregory Porphyryevich Tschebotarioff.

Gregory Porphyryevich Tschebotarioff is mentioned in all encyclopaedias as a Russian-American scholar, a specialist in soil mechanics and foundation engineering. He was born in February 1899 in Pavlovsk. His parents owned a splendid residential house in Tsarskoe Selo, a suburb of St. Petersburg.

In light of several inconsistencies in his subsequent biography I would like to clarify certain moot points based on archive materials found in St. Petersburg and specifically in the library of Saint Petersburg University of Transport, formerly known as Alexander I Institute of Transport, founded in 1809. In 2014 Saint Petersburg University of Transport regained its association with the name of that benevolent Russian Emperor Alexander I, known by many to have been its founder. This oldest establishment of education in the field of technology is also inherently connected with the name of Gregory Porphyryevich Tschebotarioff.

Gregory Porphyryevich Tschebotarioff was born not simply in the family of a Cossack officer. His father was especially close to the Russian Emperor's family, as can be now stated unequivocally, whereas his wife and mother of G.P. Tschebotarioff served as a lady-in-waiting to the Empress. Prior to the October Revolution of 1917 his father was in the rank of lieutenant-general serving in the Guards of the River Don Cossack Regiment. And one more interesting touch: G.P. Tschebotarioff’s godmother was the Dowager Empress, the mother of Tsar Nicholas II, who was deposed after the 1917 uprising.

Gregory Tschebotarioff’s first wife was Lydia Fyodorovna Krasnova, who prior to their marriage was a young friend of Tschebotarioff’s mother and resided in Detskoe Selo (currently a town of Pushkin, a suburb of St. Petersburg mentioned above). She was close to the emperor's family even through the location of her house. It was natural that generals true to the emperor, like Tschebotarioff or Krasnov, Grigory’s father in law, as well as the historic River Don ataman Kaledin, felt it a call of duty to preserve Russia's integrity by being victorious both against Germany and inside Russia itself, at the time embroiled into Bolshevik revolts, which the remaining army tried very hard to quell. Those included the well-known mass uprising on the River Don. Subsequently the forces of the so-called “Volunteers” or the White Army were fighting battles with the Red Army Corps, initially victorious but later largely unsuccessful. The last stronghold of the whites on the River Don was the city of Novocherkassk. Allegedly, it was there that Grigory Porphyryevich ended his military career. Here I would like to mention several interesting moments from the highly eventful revolution months of 1917–1918. The young Gregory Porphyryevich, having barely turned 18, was appointed a personal aide to general Krasnov, one of the combatants against the Reds in 1917–1918 in Russia. Being an expert German translator, having legal, albeit secondary education, Gregory took part in the famous talks between Krasnov, Trotsky and seaman Dybenko, which were attended also by the German military.
Now let's move to a bit of historical data, establishing the fact that his legal education began at the age of 12 when he joined the Imperial Law School. It was already during the war that he finished a concise course at Mikhailovsky Artillery School and graduated in 1916 in the rank of corporal. It was thus impossible for him to have been one of the leaders of the 'Whites' opposition neither in St. Petersburg nor on the River Don, as is sometimes believed. He doubtless must have felt deeply for them, but his chosen career at that turbulent time for Russia was that of a civil or transport engineer.

Here I have in front of me a copy of G.P. Tschebotarioff's inscription and signature on a book on soil mechanics published in the USA and presented in 1973 to professor Vladimir Petrovich Sipidin at the Department of subsoils and foundations of St. Petersburg Transport University (Figures 1 and 2). Therein Gregory Tschebotarioff designates himself a student who entered the Transport University in 1918. The inscription states that the book is being presented to be read and subsequently donated to the university library.

The full title of the book is «Foundations, retaining and earth structures». I am a member of the international community of geotechnical engineers united today by the ISSMGE, and I am really happy about the fact that G.P. Tschebotarioff had chosen his professional career at our Transport University and that amongst his colleagues, professors of soil mechanics, to whom he would subsequently present his books, were representatives of our department at St. Petersburg. Moreover, he held Russian specialists, and particularly geotechnical engineers, in high regard. Having worked in the USA for a long time he condemned politically engaged distortions of Russian history published by the USA media during the McCarthy era at the time of the so-called «cold war». It is officially known that during exchange of scientific delegations between the USA and the USSR Professor Tschebotarioff declined certain advances on the part of the CIA. Moreover, as a sign of protest he turned down the Professor Emeritus rank at Princeton. Another reason for that reaction were cases of persecution of professors of Slavic nationalities, particularly those teaching the Russian language and literature. This gives us a man of a very broad range of attention in the areas of both science and humanities.

All this does not quite endorse the image of a leader of Whites' opposition to the Reds on the river Don. At the age of 19 in 1918 he opted to come to St. Petersburg and enter the University of Transport which he could not graduate from for purely political reasons, being a member of a family close to the Russian Emperor, who were at the time being persecuted by the Soviet law enforcement agencies.

Having spoken to my senior colleagues from the field of soil mechanics and construction I confidently can bring to your attention the following moments from Gregory Tschebotarioff's youth. After entering the University of Transport he understood quite clearly that his social origins could lead to quite dramatic consequences. He was aware of what was being done to his colleagues – officers from famous St. Petersburg families, but the wish to become a professional civil engineer prevailed over the sense of self preservation danger. According to the famous professor of St. Petersburg University of Architecture and Construction (St. Petersburg Institute of Civil Engineering) and St. Petersburg Transport University Vladimir Alexeevich Gastev and professor Victor Anatolievich Florin, Gregory Tschebotarioff was interested in soil testing research in the Laboratory of Soil Mechanics at the Transport University. At that time the laboratory supervisor was the famous Russian and subsequently American professor S.P.Timoshenko. I am convinced that their ways crossed whilst still in St. Petersburg: it was in that oldest mechanical laboratory that N.M. Gersevanov conducted his pile tests (a graduate of the Transport University of 1902 and son of the rector of the University who served in that capacity for more than 25 years). Subsequently,
the leading and one of the largest specialized underground construction and foundation engineering institutes in Russia was named after N.M. Gersevanov (known today as Moscow NIIOSP). Among his student contemporaries there were N.N. Maslow and V.A. Florin who subsequently having become leading geotechnical specialists of world renown served as translators of papers and monographs by G.P. Tschebotarioff published in the USA. One can say quite confidently that since the very first days of his study at the University of Transport, being in contact with a constellation of future geotechnical gurus (S.P. Timoshenko, V.A. Gastev, N.N. Maslow, N.M. Gersevanov), he could not help getting engaged into geotechnical science which was at the time at the breaking point in terms of its importance for construction practice, and not only in Russia. He continued to maintain his ties with those bright minds also in his late years. The present writer was not spared the «geotechnical bug» that tied him to the circles of people engaged in soil mechanics after attending lectures by professor N.N. Maslov in 1957 in St. Petersburg. I was at the time a cadet of the military faculty at the University of Architecture and Construction (former Institute of Civil Engineers, later known as LISI).

According to Prof. N.N. Maslov young G.P. Tschebotarioff arrived to Berlin Technical School with notes on lectures by S.P. Timoshenko on theory of elasticity and books including publications by the Transport University Press preserved in his personal library. He profoundly impressed the examination board having presented to them his Russian knowledge in the German and English languages. According to his own testimony, Gregory Tschebotarioff had free and lengthy conversations in those languages with the members of the board and the invited leading civil engineers from the Berlin Technical School.

Sadly, fear for his life never left G.P. Tschebotarioff during the war years after the October Revolution in 1917, even after his departure to the south of Russia. Those fears were especially reinforced after he found out that some people known to him were imprisoned after their arrests and the military officers arrested in those years were loaded on ferry boats and drowned in the Gulf of Finland. This information is contained in his memoirs. I read about a lot of similar facts in Tschebotarioff's book entitled «Russia, My Native Land» published in New York in 1964 by McGrow-Hill Book Company. From this book I learned that his grandfather, whose name was also Gregory Tschebotarioff, was of Cossack stock and, a graduate of the Paris Institute of Technology, was in charge of railway construction in the South-East of Russia connecting the cities of Rostov and Voronezh in late 19th – early 20th centuries, whereas his mother Valentina Ivanovna during the war was a nurse in the military hospital at Tsarskoe Selo, where at this time the Empress Alexandra Fyodorovna was also engaged in a similar capacity. Gregory Tschebotarioff doubtless was in contact with them – his mother and his god-mother, during his sojourn while on leave in 1917 at Tsarskoe Selo, where his family resided at the time.

Initially it was with a certain degree of reluctance that I read sections on G.P. Tschebotarioff's life not connected to soil mechanics and foundation construction. But those five chapters read like an adventure story resembling «The Road to Calvary» by Alexey Tolstoy. G.P. Tschebotarioff was frequently arrested in the south of Russia but he was lucky «not to have been shot» as he himself put it in the book. Once he was mistaken by the Reds' patrol to be a «Whites' guerrilla fighter» due to a typical white officer's knapsack he was wearing, but he was spared by the timely benevolent intervention of a high-ranking official of the Reds who happened to be a former officer of the Imperial Russian Army, and a native St. Petersburger. He quietly talked to Gregory Tschebotarioff and in spite of violent protests from the blood-thirsty revolutionaries let him go. The second arrest was even more dangerous but he had time to conceal himself from the arresting brigade in the huge crowd of pro-
revolutionary populace greeting the arrival of the Red Leaders to the city of Novorossiysk. In such environment of constant threats the only solution left for him was emigration. He was evacuated to Egypt together with the College of the Don Cadets where he worked as instructor since 1921, acting as an aide to the Artillery Inspector of the Don Army. We will not be far from the truth supposing he instructed his officers in the matters of construction science because construction was the only practical field where disciplined Russian officers were in high demand, organizing and conducting building activities – there were simply no other activities ongoing in Egypt at that time.

After graduating as a civil engineer in Berlin, Gregory Tschebotarioff worked in Egypt. Demanding ground conditions of that country alerted him to the issue and importance of soil mechanics in general, and to complicacy and responsibility of foundation construction in particular. He served as a consultant in these areas for some time in France, Germany and the USA. As of 1937 he became a full-time professor at Princeton, holding a tenure in the art of construction. It is interesting to point out that directions connected to soil mechanics and foundations, including stability of retaining structures were quite rightly regarded as construction art. Gregory Tschebotarioff was involved in projects related to construction of bridges, high dams, tunnels and other civil and military structures, some of them being unique.

I would like to point out the following moments from Gregory Tschebotarioff’s notes which infused our work in ISSMGE TC 207 «Soil-Structure Interaction and Retaining Walls» for eight years (2005–2013):

- he alerted the scientific community to instances of serious discrepancy between results of large-scale and expensive in situ tests and calculations, including those behind recommended values in design standards and construction codes;
- he objectively reviewed hypotheses and theories propounded by various authors and prevalent at the time openly challenging instances of inconsistency and obsolescence;
- he reinforced understanding of soil mechanics as the theoretical foundation for calculation and computation paying specific attention to soil tests as capable of clearer representations of stressed-strained conditions in soils and structures of any degree of responsibility;
- in his book «Soil Mechanics, Foundations and Earth Structures» Prof. Tschebotarioff provides a lot of numerical data and gives a large number of numerical examples as compared to calculations according to various theories.

Below follow some highlights from a section of his book entitled «Interaction between structures, foundations and subsoils». Here is a direct quotation: «The bearing soil beneath a foundation, the foundation itself and the superstructure form a connected system and must therefore be always viewed as a unified whole». This premise was in the past too often ignored and is still sometimes overlooked by individual authors. All of it is largely connected to the complicacy of the actual problem, which was impossible to calculate efficiently with the old mathematical toolbox, that is to say without the computerized numerical modelling capabilities. Even today, theoretical background lags somewhat behind the actual contemporary construction practice, in which we have witnessed mega-deep underground structures and super-tall skyscrapers over 1000 meters tall.

Reviewing his quotes about calculations and in situ measurements one may conclude that Gregory Tschebotarioff was and has remained an ideologist for the activities of our contemporary Technical Committee №207 (Soil-Structure Interaction and Retaining Walls) of
ISSMGE, which I was fortunate enough to head for eight years (2005–2013), and which was
hosted by Russia and the Transport University.

Without looking down on the SSI related research of my contemporaries, it is important
to point out the significance of Prof. Tschebotarioff’s ideas which he even in his day and age
communicated to colleagues whilst a delegate to almost all congresses and conferences of
ISSMGE (whose abbreviation certainly changed a number of times over the years), starting
from the first 1936 congress in the USA. He frequently chaired sessions and sections, as
well as working committees on stability of retaining walls and underground structures.

In 1958 the USA and the USSR exchanged delegations of scientists and engineers. As
member of the American delegation Gregory Tschebotarioff visited Moscow, Leningrad,
Kiev and Stalingrad. He summarized his impressions in the following words: «I was leaving
with a happy feeling that my motherland – Russia – was alive and recovering after the
terrible ordeals which it had had to suffer».

Concluding my account of the life of a world-famous geotechnical specialist Gregory
Tschebotarioff, who started his career as a student of the St. Petersburg Transport University
in 1918, and developed into a great specialist at Princeton in the USA, it is relevant to
address a possible question from my geotechnical colleagues as to why it was that the mem-
bers of TC 207 “Soil-Structure interaction and retaining walls” suggested a lecture dedicated
personally to Prof. Gregory Tschebotarioff. I believe that soil-structure interaction was the
leading element in his works and, additionally, extensive systems of monitoring on large
scale projects in the USA assisted his evaluation of integrity of calculations and in situ tests.

The two sessions allowed to TC 207 “Soil-Structure Interaction and Retaining Walls” at
the 18th International Conference on Soil Mechanics and Geotechnical Engineering in Paris
in 2013 hosted about 1350 conference delegates, which demonstrates importance of our
field to the geotechnical community. We enjoyed record attendance figures, which was
pointed out in the concluding speech by the newly elected ISSMGE President Roger Frank
(France). All significant construction projects over the last 10 years have broadly imple-
mented systems of mathematical modelling in design, during construction and in subsequent
monitoring. This was conducive to unification of «the three elephants» who serve as founda-
dation for our profession both in new construction and in reconstruction. The three elephants
in question are the architect, the superstructure engineer, and the geotechnical engineer. The
reports at TC207 SSI sessions in Paris presented bold achievements implemented in design
of super-tall structures (over 1000 m) constructed in Dubai, as well as in other unique struc-
tures using state-of-the-art software engineering solutions and contemporary construction
codes (Proceedings of the TC207 workshop on soil-structure interaction and retaining walls

The geotechnical engineers of the new century have reached a new stage in numerical
calculations using advantages of contemporary computing, i.e. such as were simply not
there before. This disadvantaged level of calculation methods troubled Professor Gregory
Tschebotarioff and burdened him greatly, which he openly wrote and spoke about.

In conclusion I would like to quote our newly elected ISSMGE President Professor Rog-
er Frank: «The perspective of contemporary codes for geotechnical design will be grounded
in three words: «SOIL-STRUCTURE-INTERACTION»!

Chairman of TC207 ISSMGE (2005–2013) Professor V.M. Ulitsky (Russia)
# Table of contents

**Volume 1**

## Key-note lectures

- **V.M. Ulitsky, A.G. Shashkin, K.G. Shashkin, M.B. Lisyuk**
  Soil-structure interaction calculations of a high-rise building and subsoil consisting of sedimentary strata ................................................................. 3

- **Jean-Louis Briaud, Alireza Mirdamadi & Mojdeh Asadollahi**
  Modeling Single Piles under Lateral Impact ......................................................... 11

- **J. Gniel & C. Haberfield**
  Design, construction and performance of a tied-wall embankment supported on concrete column ground improvement ............................................................... 18

- **R. Katzenbach, S. Leppla, W. Krajewski**
  Numerical analysis and verification of the soil-structure-interaction in the course of large construction projects in inner cities ................................................. 28

- **C.F. Leung, D.E.L. Ong**
  Effects of deep excavations on adjacent foundations .......................................... 35

- **W.F. Van Impe & P.O. Van Impe**
  Comments on crushable sand stiffness relevant to soil structure interaction issues .................. 52

- **Y. El-Mossallamy**
  Pile group action under vertical compression loads ............................................. 66

## Session 1. Soil-structure interaction

- **A. Akhtarpour, M. Damghani**
  The Study of Replacing the Central Clay Core with the Plastic Concrete cut-off Wall in the Body of Soombar Reservoir Dam ........................................... 81

---

Группа компаний «Геореконструкция»  
Литература по геотехнике: http://geo-bookstore.ru
K. Ch. Avellan
Application of Soil-Foundation-Pile Interaction Design Method for Strengthening Foundations of St. John’s Church in Tartu, Estonia
Using Sustainable Manual Calculation ................................................................. 88

T. Awwad, B.E. Al-Asali
Efficiency of improving the specifications of soil lenses, that are formed near the tunnel during the stages of its investment................................. 96

G. Baykal
Three techniques for the study of soil structure interface properties; 3D roughness parameter; contact stress mapping; artificially manufactured sand........... 105

C. Jacquard
Foundations by prestressing anchors of the “Villa Méditerranée” in Marseille: from design to monitoring ............................................................... 113

Effect of Ground Motions and Tsunami Impact Force on the Performance of a Damaged River Dike ................................................................. 118

H. Hashimoto, T. Yamanashi, H. Hayashi, M. Yamaki
Influence of Thermal Condition on the Extraction Characteristics of Steel Strip Reinforcing Members ................................................................. 126

O. Z. Khalimov
Methods of Research on Frost Heave of Soil and Foundation – Freezing Soil Bulk Interaction in Terms of Seasonal Deep Frost Penetration including Areas of Pressure Migration ................................................................. 133

F. Liu, M. Jiang
Oblique pullout capacity of a single drilled pile in sandy grains cemented by methane hydrates; DEM analyses ................................................................. 142

P. V. S. N Pavan Kumar, M. R. Madhav, M. Kumar
Modeling of interaction of polymeric sheet reinforcement and backfill ................................................................. 148

D. Lombardi, V. Nappa, A. Flora
Soft grouting for the seismic protection of existing buildings ........................................................................................................ 156

L. de Moraes Pereira da Rosa, E. Maria Lopes Carvalho, Bernadete Ragoni Danziger
Soil Structure Interaction: An analysis of the effect of creep and shrinkage of concrete.... 163

E. Osman, M. Abdelmonem
Beneficial and Detrimental Effects of Seismic Soil Structure Interaction (SSI) Analysis of High Rise Buildings ........................................................................................................ 171
N. Phienwej, K. Amornfa, W. Cheang
Comparative analysis of piled foundation design of a highrise building in Bangkok subsoils.......................... 180

S. Sadek, S. Hasan
Foundation System Design for a Tall Structure on Mortar–Column-Improved Ground .... 186

H. F. Shehata
Soil, Foundation, and Superstructure Interactions of Two-Bay by Two-Bay Frames with Isolated Footings on Sand................................................................................. 194

I. Sokolić, B. Vukadinović
Design of pile group system for “Most Sava – Zeleni” railway bridge in Zagreb........... 201

E. Turk, S. Oguzhan Akbas, O. Tufenkci

M. Vaniček, I. Vaniček
Soil-structure interaction analyses for the study of nuclear power plant foundation alternatives under static and seismic loading......................................................... 213

S. Varaksin, B. Hamidi
Analysis of soil-structure interaction by Ménard pressuremeter tests and ground improvement case histories................................................................. 219

N. Vyaltsev
Monitoring based analysis of interaction between an integral bridge and GSY-reinforced embankment .................................................................................. 226

L. Vollmert, J. Schlee
Piled embankments in soft estuary clay – Experience from design and field measurements for redevelopment of harbour areas in Northern Germany............... 231

Youpele O. Beredugo
Vibration of dynamically loaded foundations partially embedded in an elastic stratum.... 239

Zhuang Haiyang, Yu Xu, Zhu Chao
An efficient method for estimating the dynamic response of base-isolated structure with SSI effect ........................................................................................................ 247

A.Zh. Zhussupbekov, N.T. Alibekova, I.O. Morev, Ye.B. Utepov
Determination of bearing capacity of the precast piles by dynamic cone penetration test (DCPT)................................................................. 255
Session 2. Underground structures and retaining walls

C.W. Ong, Su Thiri, K.Y. Yong, Ariaratnam Kulaindran
Understanding of Soil Responses due to Tunnelling – 3D Numerical Analysis and Case Study of Bendemeer Station (DTL-3), Singapore ................................................................. 262-1

A. Adekunte
An investigation into the vertical axial capacities and groundwater cut-off capabilities of secant pile walls ........................................................................................................ 263

Ö. Akçakal, T. Durgunoğlu, B. Koçak, T. Tari
3D Modelling in Deep Excavations – Case Studies ........................................................................ 271

Bruno Becci & Marco Carni
Pseudo-static analysis of flexible retaining structures including seismic thrust dependency on wall deformation ................................................................................................. 277

Ö. Bilgin
Soil-structure interaction for sheet pile walls considering ground surface and sub-wall soil conditions .................................................................................................................. 285

C. Jurado Cabañas
Seismic Soil-Interaction on Earth Retaining Structures. Performance-based seismic design of a Retaining Wall .................................................................................................... 291

T. Chernova, Ö. Bilgin, N. Tsimbelman
Overview of Shells with Infill used in Geotechnical Engineering Applications .................. 297

A. Edinçiler & Y. S. Toksoy
Investigation on Effects of Tire Crumb Cushion on Seismic Performance of Retaining Wall ................................................................................................................................. 305

H. Elahi, M. Sabermahani, H. Vahidifard
Shoring-structure interaction in stabilization of excavation adjacent to historic buildings – A Case Study .................................................................................................................. 310

D.S. Kim, S.Y. Park
Design and construction of reinforced retaining wall in the railway of Korea.................................. 316

C.E.M. Maffei, H.H.S. Gonçalves, M.C. Guazzelli
A bold constructive method for the retaining structures of the excavation of the underground parking Clinics, in Brazil .................................................................................. 320

C.E.M. Maffei, H.H.S. Gonçalves, M.C. Guazzelli, J.P. Ciriacdes, P.E.M. Maffei & R.A. Simoni & C. Goulart
Deepening of some Brazilian quays using the technique of reinforced jet-grouting ........ 328

S. Melentijevic & J.L. Fernández
Comparison of finite element and limit equilibrium methods in analysis of soil nail walls ................................................................................................................................. 334

Группа компаний «Геореконструкция»
Литература по геотехнике: http://geo-bookstore.ru
M.A. Putera Agung, S. Pramusandi, A. Ardianto, B. Sunaryo
Assessment Analysis of Lateral Movement of Gate Shaft Structure
on Fractured Rock Mass, Jatigede Dam Area, West Java, Indonesia .............................. 342

L. A. Estevez Rey & N. A. Daza Rodríguez
A case study of a Deep Excavation on Soft Lacustrine Clay of Bogota, Colombia,
with emphasis between Predicted and Measured deformations ................................. 350

G. Russo, S. Autuori, M.V. Nicotera
San Pasquale station of the Linea 6 in Napoli:
dewatering field tests, measurements and back-analyses ........................................ 358

A. Sato, T. Yamanashi, T. Suzuki, N. Tatta, K. Yoshida
Frost Protection for Geotextile-reinforced Soil Walls in Service .............................. 366

S.V. Sivapriya, S.R. Gandhi
Evaluation of pile behaviour on sloping clayey soil in supporting a diaphragm wall
for building excavation ..................................................................................................... 374

H.F. Shehata, T.M. Sorour
Effect of Base Soil Stiffness on the Earth Pressure of Cantilever Retaining Walls ........ 379

J.C. Solis Tito, C. Romanel
Numerical Analysis 3D of a Deep Circular Excavation in the City of Rio de Janeiro .... 385

A. Soroush, & M. Hashemzadeh
Finite element analysis of the soil type effect on buried pipelines
under strike-slip faulting .................................................................................................. 392

P. Tanseng & V. Namwiset
Performance of soil-cement column retaining wall used with top-down
construction method for basement construction in Bangkok subsoil ........................... 399

Session 3. Site investigation as source of input parameters for soil-structure interaction

M. Abu Sadeque, Partha Saha, A.R.M. Farid Uddin
Standard Penetration Test and Its Discrepancies in Bangladesh Perspective:
A Comparative Study Between Automatic Trip Hammer And Donut Hammer .......... 409

A. El Khoury, Imad Esta, Jean B. Esta
Test for Determining Mechanical Characteristics of Any Rocky ............................... 413

C. L. Zenti, A. Bellocchio, D. Sterpi
Laboratory and In-Situ testing for the identification of bonding parameters
of GFRP pipes and soil nailing systems ....................................................................... 415
The Study of Replacing the Central Clay Core with the Plastic Concrete cut-off Wall in the Body of Soombar Reservoir Dam

Ali Akhtarpour, Assistant Professor, Ferdowsi University of Mashhad, Civil Engineering Department, Iran
Mahdis Damghani, Msc. Student of international branch of Ferdowsi University, Civil Engineering Department, Iran

ABSTRACT: Due to proper technical characteristics, economic and operating considerations, the clay core earth dams have such a special place in the world. In this kind of dams, the implementation of their core and adjacent filters are placed in the critical path of dam construction, while the coarse grain shells are performable easily and quickly. Considering this fact, the possibility of replacing the clay core with other appropriate sealing materials, has been studied. The discussed idea in this field is the implementation of plastic concrete in the center of the dam body with the stage drilling in coarse grain shells. The most concern are related to the rigidity of the plastic concrete wall in comparison with the dam’s gravelly shells and also the pressure and tension/stress transfer to the wall in the dynamic and static conditions. In this paper, with a numerical method, the performance of the proposed cut-off wall in the body of a reservoir dam (Soombar reservoir dam) The static analyses show there is a possibility of developing cracks in cut-off wall, and due to technical issues this replacement is not possible for Soombar dam.

Keywords: Earth dam, clay core, sealing wall, plastic concrete, cut-off wall

1) Introduction and Introducing the Dam

Soombar River is under construction along the border of Iran and Turkmenistan in the north of North Khorasan province, in order to set the river’s water for the agriculture usages. The primary plan of the dam includes a earth dam with a wide central clay core with a height of about 23.5 meters from the alluvial foundation, which is located on a weak saturated silty clay alluvium with a maximum depth of 30 meters. Selection of large width for the clay core is first because of the existence of large volume of fine soil in the reservoir of the dam and also the limitations of volume in coarse grain materials in the plan region, and second because of compressibility of the alluvium. The sealing of the alluvium foundation is provided by a plastic concrete cut-off wall to a depth of 18 meters. In figure 1 you can see the cross section type of the dam body.

![Figure 1- Cross Section Type Body of Soombar Dam](image-url)

According to this fact that this project has been on the accelerated plans list of the management, the project review meetings were held in the form of value engineering. At the time of this review, major part of the cut-off wall in the dam foundation has been constructed, and also one part of the dam shells has been constructed from the coarse grain materials in the upstream and downstream area of the body. The main problems of the contractor are filter material production, drainage, and also clay core process and implementation. Therefore, the option of replacing the central clay core in the dam body with the plastic concrete sealing wall has been introduced with the aim of reducing or removing the filters and the core. In this paper, based on technical documentation and the parameters of the body and foundation materials in the approved technical report, the feasibility of this replacement is discussed.

2) Stress-Strain Analysis in the Finite-Element Method

Evaluating the behavior of stress-strain and deformation of embankment dams is important and desirable from two perspectives of stability and reliable service. In analyzing the stress-strain, the highest cross section of the dam has been used. It’s obvious that constructing the cut-off wall up to the dam crest will make some changes to the strain-stress distribution in
the foundation cut-off wall. So the sealing wall sustainability should be measured in both the foundation and the body. The stress-strain analysis has been done by Sigma/W, a computer program, which is a finite-element program for soil structures analysis from the program package of Geostudio 2007. The Elasto-plastic model was used for the numerical analysis, and in this model there is the possibility of stage loading and modeling the excavation and embankment. In the final stage of construction, the dam body will be constructed in 14 layers. In figure 2, you can see the finite-element grid which is used in the finite-element analysis.

Furthermore, a series of similar analyses has been done on the primary cross section of the dam (clay core), and the strains in foundation sealing wall has been measured. In figure 3, you can see the cross section which is used for analyzing this case.

The considered parameters for the Sombar dam body in the stress-strain analysis by the finite-element method are based on the studies of the detail stage studies which are shown in table 1. Cut-off wall parameters are determined based on the quality control tests of the materials in the sealing wall construction of foundation dam.

<table>
<thead>
<tr>
<th>Material</th>
<th>( \rho (\text{Kg/m}^3) )</th>
<th>( E (\text{Kpa}) )</th>
<th>( C (\text{Kpa}) )</th>
<th>( k )</th>
<th>( V )</th>
<th>( (\varphi') )</th>
</tr>
</thead>
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<tr>
<td>Area 1 shell</td>
<td>22</td>
<td>40000</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>42</td>
</tr>
<tr>
<td>Area 2 alluvial foundation C.D</td>
<td>19</td>
<td>11800</td>
<td>50</td>
<td>0.5</td>
<td>0.3</td>
<td>20</td>
</tr>
<tr>
<td>Area 2 alluvial foundation C.U</td>
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<td>14160</td>
<td>50</td>
<td>0.5</td>
<td>0.48</td>
<td>14</td>
</tr>
<tr>
<td>Area 3 transfer area</td>
<td>20</td>
<td>20000</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>33</td>
</tr>
<tr>
<td>Area 4 cut-off well</td>
<td>22</td>
<td>600000</td>
<td>600</td>
<td>-</td>
<td>0.2</td>
<td>35</td>
</tr>
</tbody>
</table>

3) Static Analysis Results in the Finite-Element Method

3.1) Stresses

Total horizontal and vertical stresses in different parts of the foundation and dam body at the end of the dam construction have been shown in the figures 4 and 5. As you can see, the horizontal and vertical stress distribution in upstream and downstream of the body and foundation are almost symmetrical. The difference between the material characteristics of the sealing wall with the characteristics of its adjacent material leads to the transfer of stress from adjacent material to the wall. Due to the relative plasticity of alluvial foundation, this process somewhat continues in the alluvial foundation and causes the transmission of forces to the plastic concrete.

In figure 6, you can see the total vertical stresses in different levels of the central plastic concrete sealing wall at the end stage of construction (crest level is 1237/5). It can be seen that the maximum horizontal stress has come to approximately 1200 (at the area of the alluvial foundation). Figure 7 shows the maximum shear stresses in the center of sealing wall in different levels at the end of the construction stage. Like vertical stresses, the maximum shear stress has come to the level of 1200 and has happened in the upstream range of alluvial foundation.
3.2) Displacements

The vertical and horizontal displacements in this analysis are illustrated in figures 8 and 9. As you can see, upstream and downstream displacements of the dam are almost symmetrical. Maximum horizontal displacements in upstream are calculated as 12 centimeters and in downstream are calculated as 14 centimeters. The reason of this little difference in the horizontal displacements in downstream and upstream of the dam is the slope angle difference between the upstream and downstream shells. The vertical displacement in the center of dam reaches to maximum 84 centimeters. The above said displacements are compensated by the additional embankment at the end of the construction.

In figures 10 and 11, the shear and vertical strains in different levels of downstream area of the wall in the position of plan implementation of plastic concrete sealing wall up to crest level at the end stage are demonstrated. Again, it can be understood that constructing the sealing wall up to the dam crest can increase the strains in sealing wall of the foundation area. The very important point is that at the end of construction state of the dam, the plastic concrete will experience vertical strains of about 1.7 percent which, based on the existing laboratory tests, cause the failure in the wall.

4) Examining the failure of the plastic concrete wall

In order to evaluate the sustainability in plastic concrete wall in the static condition, stress Mohr circles has been studied in numerical analysis of three levels of sealing wall in the dam body, on the alluvium and in the alluvial foundation. The position of these points has been shown in figure 12.
Mohr Circle 3-Elevation 1213
Mohr Circle 2-Elevation 1210
Mohr Circle 1-Elevation 1207

Figure 12- The Position of the Mohr Circles in the Direction of the Wall

Figure 13- The Force Distribution in the 1213 Level Related to the Mohr Circle Number 1

Figure 14- The Force Distribution in the 1210 Level Related to the Mohr Circle Number 2

Figure 15- The Force Distribution in the 1207 Level Related to the Mohr Circle Number 3

Also in figures 13 to 15, you can see the stress Mohr circles in these points.

As a sample of related calculations of Mohr circle, figure 3 shows that the plastic concrete wall can't bear the force, and in the static condition, its failure is indispensable. The similar calculations show failure in all three points.

\[
\sigma_1 = \sigma_t \tan^2(45 + \frac{\phi}{2}) + 2C \tan(45 + \frac{\phi}{2})
\]

\[
F_r = \sigma_1 \tan^2(62.5) + 1200 \tan(62.5) = 3246 \text{ KPa} < \sigma_{	ext{yield}} = 3439 \text{ KPa}
\]

In order to check the reliability of the obtained results from the Geostudio software, version 2007, similar analyses were performed with the Plaxis 8.2 software. Soombar dam body has been modeled in 15 layers and in numerical analysis the previous parameters have been used. Total, vertical, and horizontal subsidence in the dam body is similar to the analysis results of Geostudio whose presentation is avoided here.

The developed stress in the sealing wall and plastic points in it have been shown in figures 16 and 17. In figure 18, the vertical stress distribution of the wall has been demonstrated. Figure 16 clearly shows the concentration of the horizontal stress in the sealing wall especially in the alluvial foundation area. In view of figure 17, it can be understood that the concentration of the plastic points happens in the body and wall in the area on the alluvial foundation. Therefore, the shear failure of the sealing wall in this area is possible.
5) Conclusions

The stress-strain analyses show that the failure in sealing wall happens in the dam body and foundation at the end of dam construction. So, with no more studies on loading conditions caused by the filling and earthquake conditions, this option is technically considered excluded. Furthermore, without any calculations and with a review of the dynamic analysis results of technical report of the plan’s second stage, it can be said that in case of an earthquake, the instability in plastic concrete will also be noticed. Totally, the replacement of the clay core with the plastic concrete sealing wall for the constructed dams on the subsiding alluvial foundation is not advised.

Furthermore, for the dams constructed on the rock, it is needed to examine the static and dynamic loading conditions by considering the stiffness differences of the wall with its adjacent materials and also the brittleness of the plastic concrete (in comparison with the soil).

References:


