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MONTEERITAVATEST ELEMENTIDEST CON/SPAN SILLA JA INTEGRAALSILLA VÕRDLUS OARA SILLA (NR. 715) NÄITEL

COMPARISON OF PRECAST CON/SPAN BRIDGE SYSTEM AND INTEGRAL BRIDGE ON OARA BRIDGE (NR. 715) EXAMPLE

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KOKKUVÕTE

CON/SPAN ja integraalsilla võrdlemise käigus koostati kaks mudelit lõplike elementide tarkvarades. CON/SPAN modelleerimisel kasutati tarkvara PLAXIS 2D, integraalsilla puhul kasutati tarkvara STAAD Pro.

PLAXIS 2D tarkvaras tuleb võimalikult täpse mudeli koostamiseks teada täpseid pinnase parameetreid, mida CON/SPAN rajatise ehitamisel kasutatakse. Detailsete pinnase parameetrite saamiseks tuleb teostada kolmtelg surve katse, mida Eestis väga laialdaselt ei praktiseerita. Alternatiivina saab mudeli koostamisel kasutada pinnase liigist sõltuvaid üldiselt tuntud pinnase parameetreid, kuid sellisel juhul on saadud arvutustulemused üldjuhul konservatiivsemad.

Arvutustulemustest selgub, et määravaks koormuseks CON/SPAN silla puhul osutub KM3. Integraalsilla puhul põhjustas silla avas suurimaid sisejõude sümmeetriliselt paigutatud liikluskoormus KM1 ning toel põhjustas suurimaid sisejõud toele paigutatud liikluskoormus KM3. Saadud tulemuste põhjal on teostatud sildade armatuuri dimensioonimine ning kontrollarvutused kande- ja kasutuspiirseisundis. Kusjuures CON/SPAN rajatise ristlõike armatuuri dimensioonimisel osutus määravaks kasutuspiirseisundist tulenev pragudekontroll.

Saadud tulemuste põhjal koostati sildade ehitusmaksumuste hindamiseks vajalike tööde loetelu koos tööde mahtude ning hinnanguliste ühikhinna maksumustega. Ehitusmaksumuste võrdlemisel selgub, et CON/SPAN silla rajamise maksumus on suurem kui integraalsilla puhul. Samas on CON/SPAN silla eeliseks oluliselt lühem ehituskestus ning tööde teostamise lihtsus. CON/SPAN silla rajamine ei nõua üldjuhul ehitusplatsil selliste tööde tegemist nagu armeerimine ja raketise ehitus. Integraalsilla ehituskestus on märgatavalt pikem kui CON/SPAN sillal, see toob endaga kaasa kõrgema kogumaksumuse sotsiaalse komponendi arvelt.

Autor leiab, et kahe silla ehitusmaksumuse võrdlus ei ole piisav rajatava sillatüübi lõpliku valiku tegemiseks. Lisaks ehitusmaksumusele tuleks hinnata silla kogumaksumust, kus on arvesse võetud ka sotsiaalse komponendi ehitusaegne kulu. Kogumaksumuse sotsiaalse komponendi hindamine annab ülevaate erinevate sillatüüpide rajamisel kaasnevatest otsestest ja kaudsetest kuludest, mis võivad osutuda määravaks rajatava sillatüübi valimisel. Rajatiste kogumaksumuse sotsiaalse komponendi hindamine on eriti aktuaalne olukordades, kus teekasutajal tuleb silla ehituskestuse vältel kasutada ajutist ümbersõiduteed. Käesolevas töös ei ole sildade kogumaksumust ja selle sotsiaalset komponenti teema mahu piirangu tõttu lähemalt uuritud.

Käesoleval hetkel ei ole sotsiaalse kulu hindamine Eestis laialdaselt levinud, samuti puudub selleks vajalik Eesti oludes rakendatav metoodika. Autor leiab, et rajatise ehitusaegne sotsiaalne kulu ja selle mõju rajatise kogumaksumusele Eesti tingimustes vajab edasist lähemat uurimist.

SUMMARY

Bridge is a one or multi-span structure carrying road or a path across a river, road or other obstacle and has at least one span with length of 3,0 m or more. Majority of bridges in Estonia are short concrete bridges with span not more than 25 m.

First aim of this thesis is to introduce a structure called CON/SPAN Bridge System and the required static calculation method to design the structure. CON/SPAN Bridge System is a precast buried bridge structure that consists of modular precast reinforced concrete elements for total set-in-place construction of bridges, culverts and underground structures. Buried bridge in this case is a type of bridge where precast reinforced concrete elements in combination with surrounding soil form a structure that can carry load. Second aim of this thesis is to compare CON/SPAN Bridge System with traditional concrete bridge (in this case integral bridge) on Oara bridge example.

In comparison process of CON/SPAN Bridge System and integral bridge, two finite element models were made to determine occurring internal forces caused by live load in each bridge. CON/SPAN structure was modelled in finite element software for geotechnical analysis called PLAXIS 2D and integral bridge was modelled in a structural analysis and design software called STAAD Pro.

The soil material in PLAXIS 2D can be simulated using different material models. Some of those models require precise soil properties input data, which can be obtained from triaxial shear test. However, this test is not commonly used in Estonia. Alternatively, more simple soil model can be used, which requires less precise input data and can be performed knowing general soil properties that are defined by soil type. Although, using simplified soil model in general leads to more conservative analysis results.

FEM analysis show that most critical load for CON/SPAN Bridge System is load model LM3. In case of integral bridge, the most critical load model for determining internal forces in the span was LM1. Highest internal forces in area of abutment were caused by load model LM3 placed directly over the abutment. Required rebars for both bridges were dimensioned based on the internal force results from the two finite element softwares. Afterwards ultimate limit state (ULS) and serviceability limit state (SLS) checks were made. In case CON/SPAN Bridge System required rebars were determined by SLS crack control check requirement.

Based on acquired results the construction costs were estimated by composing cost list including all necessary construction works and volumes with prices for constructing both bridges. In

comparison of these construction costs it turned out that construction price of CON/SPAN Bridge System is more expensive (by 12 555,10 €) than construction price of integral bridge. However, the advantage of CON/SPAN is its short construction time and construction simplicity. In this case CON/SPAN construction time is significantly shorter than integral bridge construction time, 14 days and 140 days respectively. Construction time of integral bridge causes additional social costs, which influence the whole cost of bridge construction in general.

From this author finds it to be evident, that comparing two bridges based only on their construction cost is not sufficient for deciding on whether which bridge will be constructed. Instead social costs caused by bridge construction should be also included to the comparison. The impact of social cost in bridge construction is especially vital in situations when the road, on which the bridge is going to be constructed, will be closed and detour road is required for the construction period. Social costs from construction of CON/SPAN Bridge System and integral bridge are not examined herein due to content limitation of the thesis.

Evaluation of social costs caused by construction is not widely known and used in Estonia in general. Also, there is no social cost evaluation method which would take in account local conditions at this point. Author finds that evaluating social costs caused by construction of bridges in Estonia needs further investigation