SUND OG BÆLT

ANALYSER AF FREMSKUDT FÆRGEHAVN VED TÅRS

KONCEPTDESIGN AF BROER

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INDHOLD

BILAG

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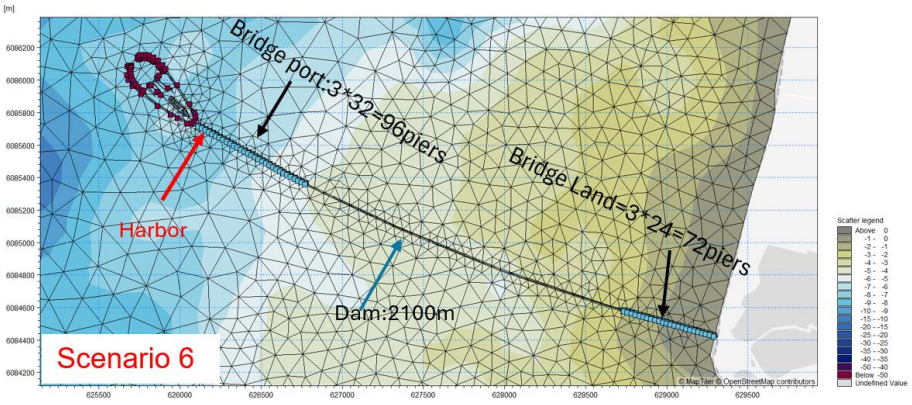
1 Indledning

Den fremskudte havn forbindes til Lolland med en ca. 3,5 km lang adgangsvej, der består af lavbro(er) og/eller dæmning(er). Broer har generelt mindre påvirkning af vandgennemstrømningen i forhold til dæmninger.

Dette tekniske notat indeholder en beskrivelse af mulige broløsninger som en del af adgangsvejen mellem fastlandet og den kunstige ø med en fremskudt færgehavn ved Tårs.

Udgangspunktet er en løsning med en kombination af to broer med længder på 600 m og 800 m og en 2100 m dæmning med en samlet længde på ca. 3,5 km mellem fastlandet og den fremskudte havn, se Figur 1. Den inderste bro sikrer fortsat sandtransport langs kysten, og den yderste bro giver reduceret påvirkning af vandgennemstrømningen. Beskrivelserne af mulige løsninger kan også bruges for en ren broforbindelse samt for alternativer med andre kombinationer af broer og dæmninger.



Figur 1 Løsning med en kombination af to broer og en dæmning.

Indledningsvist er der foretaget en undersøgelse af den optimale spændvidde af broerne ved at se på mængden af anvendt beton. Efterfølgende er der set på mulige byggemetoder pga. den lave vanddybde i området, især for en bro startende ved fastlandet.

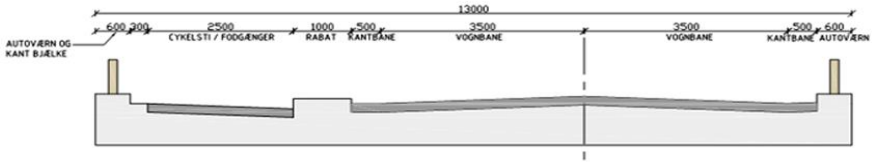
2 Undersøgelse af spændvidder

En undersøgelse af mængden af beton for en 3,5 km lang betonbro er foretaget med forskellige spændvidder. Broen kan udføres enten som en præfabrikeret bro eller som en in-situ støbt bro.

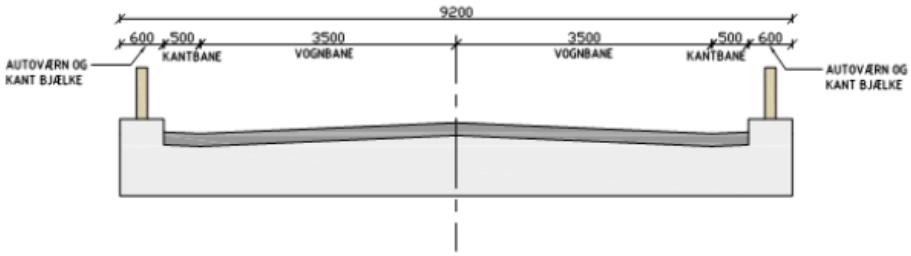
I denne indledende analyse er der set på egenvægtens belastning, bevægelig last og vandret belastning i form af bremsekræfter. Der er ikke set på påvirkninger ifm. skibsstød, der kan have en indvirkning på søjlerne (bropiller).

Et typisk tværsnit af overbygningen med en cykelsti er anvendt i undersøgelsen af spændvidder og vist i Figur 2. Tværsnittet består af to vognbaner med en bredde på 3,5 m samt en dobbeltsporet cykelsti med en bredde på 2,5 m. Den totale bredde inklusive kantbaner, rabat og autoværn er 13,0 m.

Bredden af et typisk tværsnit af brooverbygningen uden cykelsti er 9,2 m som vist i Figur 3.



Figur 2 *Tværsnit af overbygning med cykelsti.*



Figur 3 *Tværsnit af overbygning uden cykelsti.*

Underbygningen er antaget at bestå af 3 bropiller per brofag, der er placeret på et fundament gravet ned i havbunden. Diametre af bropiller og størrelse af fundamenter er angivet i Tabel 1.

I analysen af spændvidder er der fokuseret på diameteren af bropiller til underbygningen, idet diameteren vil have betydning for påvirkningen af vandgennemstrømningen.

Resultatet af analyserne for spændvidder fra 25 til 55 m for en brokonstruktion med cykelsti viser, at mængden af beton er stigende med spændvidden, se Tabel 1. Derfor er en spændvidde på 25 m anvendt. Det vil dog være formålstjenligt i en senere fase af projektet at overveje, om der kan være overordnede fordele ved at vælge større spændvidder, f.eks. i forbindelse med valg af byggemetode.

Tabel 1 Analyse af brokonstruktion med cykelsti for forskellige spændvidder

Spændvidde [m]	Diameter bropiller [m]	Fudaments-bredde [m]	Fundaments-tykkelse [m]	Fundaments-længde [m]	Beton under-bygning pr. fag [m³]	Samlet be-tonmængde per. fag [m³]	Beton-mængde pr. m² fag [m³/m²]	Beton-mængde to-tal [m³]
25	0,80	2,8	1,00	11,0	41	220	0,68	30.738
30	0,90	3,0	1,00	11,0	46	271	0,69	31.571
35	1,00	3,5	1,25	11,0	65	338	0,74	33.762
40	1,00	3,8	1,38	11,0	73	393	0,76	34.389
45	1,10	4,0	1,50	11,0	86	452	0,77	35.123
50	1,20	4,5	1,75	11,0	110	533	0,82	37.301
55	1,30	5,0	2,00	11,0	138	620	0,87	39.486

De begrænsede geologiske profiler i området viser, at der primært er moræneler fra havbundsniveau. Geotekniske parametre er bestemt for moræneler som beskrevet i Bilag A. Disse geotekniske parametre er brugt til at verificere at størrelsen af fundamenterne er stabile, se fundamentsberegninger i Bilag B.

3 Kote til underside af bro

Koten til undersiden af broen skal tage hensyn til bølgetoppen for den maksimale bølgehøjde og højvandstand under en stormhændelse.

Under forudsætning af at storme i området har en varighed på ca. 3 timer, så vil den maksimale bølgehøjde være ca. H_{max} = 1,86xH_{m0} (H_{m0} er den signifikante bølgehøjde). Ifølge DNV-ST-0437, ref. /1/, ligger bølgeperioden for den maksimale bølgehøjde i intervallet:

$$11.1\sqrt{H_s/g} = T_{min} < T < T_{max} = 14.3\sqrt{H_s/g}$$

Bølgetoppen for den maksimale bølgehøjde beregnes ved hjælp af ikke-lineære strømfunktionsteori.

En bro skal udføres med en kote til undersiden, hvor der er tilstrækkelig luft mellem designbølgen og broens underside. For design benyttes et "air-gap" på 0,5 m.

Kote til underside af bro er bestemt for en 10 og 200-års stormhændelse for bølgeretningerne 0, 30, 60, 180, 210 og 240°N, der forventes at være dimensionsgivende. Resultater fremgår af Tabel 2. Design vandstande og de signifikante bølgehøjder er tilsvarende dem præsenteret i ref. /2/. Der er benyttet en havbundskote på -7,0 m DVR90.

Det er normal international praksis at sikre, at broer opføres i en højde, så de ikke rammes af bølgetoppen under dimensionsgivende designforhold. For indeværende analyser benyttes en 200-års designhændelse, jf. ref. /2/, hvorfor broens underside skal placeres i kote +6,5 m DVR90 eller højere. Koten til broens underside bør fastholdes på hele den yderste lavbro (800 m lang), som forbindes med den fremskudte havn.

For lavbroen som forbindes til land (600 m lang), kan der benyttes en lavere kote til broens underside, da havbundskoten er reduceret til 0 til -2,0 m DVR90, samtidig med at der nær kysten vil ske refraktion af bølgerne. Bølgehøjderne fra 30 og 60°N vil samtidig være væsentlig reduceret på grund af et kort frit stræk. Denne kote skal bestemmes i senere fase.

Koten til undersiden af broen er bestemt på baggrund af havspejlsstigninger svarende til klimascenarie SSP2-4.5, se ref. /2/. Hvis der ønskes en større sikkerhed i forbindelse med vandstandsstigninger, kan det i en senere fase undersøges om et værre klimascenarie skal analyseres og koten af broens underside øges.

Tabel 2 Minimum kote af bro-underside for 10- og 200-års returperiode.

Retning [°N]	Design vandstand [m DVR90]	Effektiv vand-dybde [m]	Returperi-ode [år]	H_{m0} [m]	H_{max} [m]	T_{min} [s]	T_{max} [s]	Bølgetop [m]	Min. kote af bro-un-derside** [mDVR90]
0	1,68	8,68	200	3	5,6	6,1	7,9	4,27	**6,5**
	1,68	8,68	10	1,8	3,3	4,8	6,1	2,06	4,2
30	1,18	8,18	200	1,7	3,2	4,6	5,9	2,01	3,7
	1,38	8,38	10	1,4	2,6	4,2	5,4	1,56	3,4
60	2,72	9,72	200	1,6	3,0	4,5	5,8	1,79	5,0
	1,38	8,38	10	1,2	2,2	3,9	5,0	1,29	3,2
180	0,98	7,98	200	1,3	2,4	4,0	5,2	1,43	2,9
	1,18	8,18	10	1,2	2,2	3,9	5,0	1,29	3,0
210	0,98	7,98	200	3,1	5,8	6,2	8,0	4,23*	5,7
	1,08	8,08	10	2,2	4,1	5,3	6,8	2,82	**4,4**
240	0,98	7,98	200	3,1	5,8	6,2	8,0	4,23*	5,7
	1,08	8,08	10	2,2	4,1	5,3	6,8	2,82	**4,4**

* Den maksimale

** Beregnet med design vandstand + bølgetop + "air-gap" på 0,5m. Værdier er afrundet.

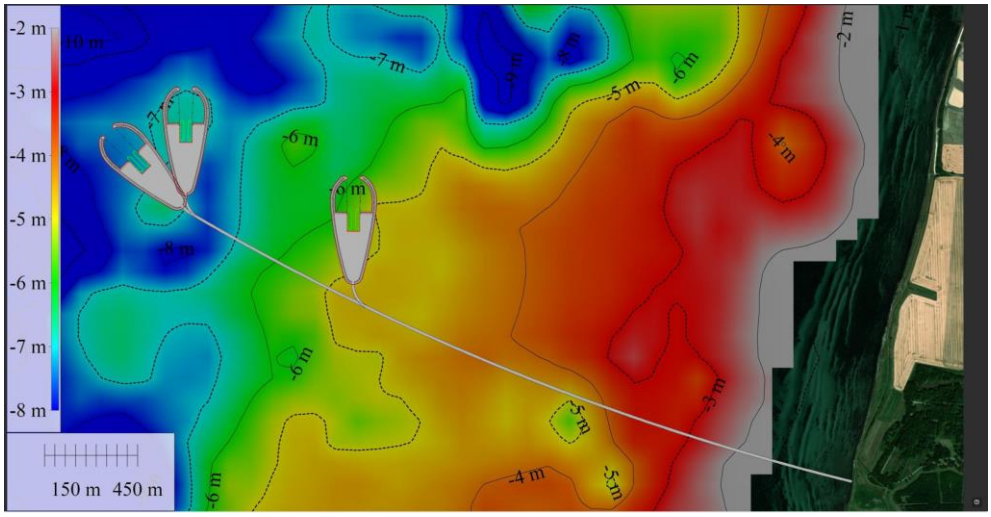
Det er særlig vigtigt for konstruktioner som broer, der generelt ikke senere kan ændres i højde/kote, at de fra starten opføres i en tilstrækkelig højde/kote. Til sammenligning er situationen anderledes for en stenkastning eller mole, som hvis der er plads, relativt let og uden meget store omkostninger kan hæves/forstærkes på et senere tidspunkt, når/hvis vandstanden i havet er steget signifikant.

Hvis der vælges en kote, så broen rammes af bølgetoppe, bør der foretages beregninger, som viser at broen strukturelt kan optage bølgelasten fra "slamming", når bølgen rammer.

En sådan alternativ løsning kan undersøges i forbindelse med en optimering af broen. Det må forventes, at der ikke er trafik på broen under den ekstreme stormhændelse svarende til en designhændelse med en returperiode på 10 år. For det tilfælde kan det eventuelt accepteres, at de højeste bølger rammer broen, hvorved koten på +6,5 m DVR90 til underside af broen kan reduceres. Hvis det antages, at de højeste bølger ikke må ramme broen for en designbølge med en returperiode på 10 år, viser resultaterne i Tabel 2, at broens underside kan placeres i kote +4,4 m DVR90 eller højere. Dette vil dog være på bekostning af, at broen skal designes for bølgelaster for en 200-års hændelse, hvilket vil øge dimensionerne på konstruktionselementerne, da overbygningen vil få en større horisontal bølgebelastning.

4 Byggemetode

Det er vigtigt at tage højde for den varierende vanddybde inden for projektområdet, når byggemetoden overvejes, se Figur 4.



Figur 4 Vanddybder. Angivet i m DVR90.

Linjeføringens startpunkt er gengivet i Figur 5.

Figur 5 Placering af vederlag til bro.

I det følgende er forskellige udførelsesmetoder beskrevet for gennemførelsen af en konkret teknisk løsning af adgangsvejen, dvs. en given kombination af broer og dæmning. Beskrivelsen kan tilpasses til tekniske løsninger med andre kombinationer af broer og dæmninger. Den konkrete tekniske løsning for etablering af en fremskudt havn ca. 3,5 km fra den eksisterende kyst omfatter følgende hovedelementer:

- Først ca. 600 meter brostrækning fra eksisterende kyst, der skal udføres på vanddybder mindre end 2 meter. For ikke at berøre den eksisterende kyst mere end nødvendigt, antages det, at broen starter bag diget, der løber ca. 20 m bag kysten.
- Herefter ca. 2,1 km dæmningsstrækning
- Dernæst ca. 800 meter brostrækning ud til den fremskudte havn som udføres på vanddybder større end 5 m.

Broen på dybere vand vil højest sandsynligt blive bygget med udførelse fra havet, da vanddybden tillader brug af pram til anlæg af underbygning og dernæst overbygning ved fuldfagsmetode. Det naturlige valg for en entreprenør vil derfor være at bruge samme metode for den kystnære bro på lavt vand.

Nedenfor er først beskrevet en løsning for udførelse af den inderste 600 meter bro-strækning med udgangspunkt i førnævnte metode, hvortil det er nødvendigt at uddybe en rende således at pramme kan komme ind på de laverede vanddybder, jf. afsnit 4.1. Et alternativ er at bygge den inderste bro med udførelse fra land ved først at bygge en midlertidig dæmning, jf. afsnit 4.2.

Den del af broen som udføres på vanddybder større end 5 meter beskrives efterfølgende, og der vil til dels være en tidsmæssig afhængighed af udførelsen af den kystnære bro samt dæmningen.

4.1 Bro på lavt vand med udførelse fra havet

Indledningsvis uddybes en rende svarende til mindst broens bredde på ca. 15 m plus et område på ca. 15 m langs broen hvorfra udstyr så som pramme kan bygge broen, dvs. i alt en rende på ca. 30 m. Rendens dybde afhænger af hvilket udstyr, der skal bruges til udførelse af broen, en dybde på ca. 3 m er vurderet tilstrækkelig. En backhoe dredger vil eksempelvis kunne bruges til uddybning af renden, idet uddybningsdybden er begrænset.

Figur 6 Backhoe dredger.

4.1.1 Underbygning

Broen kan enten funderes direkte på havbunden som undersøgt ifm. undersøgelsen af spændvidder i afsnit 2 eller funderes på pæle (borede eller rammede) med efterfølgende søjler og bjælker.

Broens understøtninger anlægges med udstyr på en pram, der successivt anlægger én understøtning ad gangen.

Figur 7 Pram med boreudstyr for pæle.

Hvis det vurderes at ulemperne ved, at der er betydelig ventetid for boremateriel til pæle mens bjælker og evt. søjler anlægges, må disse aktiviteter adskilles i to forskellige og uafhængige arbejdsgange og dermed to pramme. To pramme kan passere hinanden ved, at den ene midlertidigt sejler ind i uddybningen mellem understøtningerne. Anvendelse af to primære pramme for udførelse af underbygningen er langt mindre tidskrævende ift. til arbejdsgangen hvor én pram faciliterer udførelse af hele underbygningen.

4.1.2 Overbygning

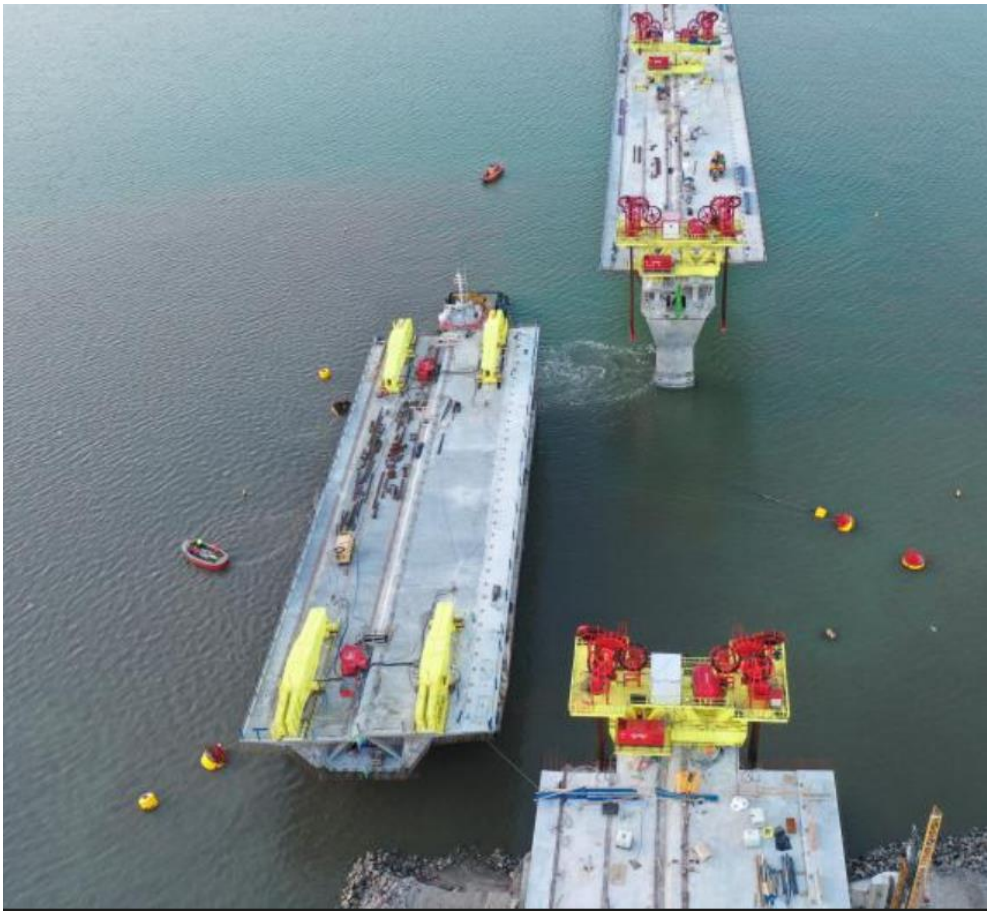
Ved anlæggelse af overbygningen fra havet tages der udgangspunktet i fuldfagsmetoden, da dette forventes at være den foretrukne anlægsmetode for broen på dybere vand. Der er andre mulige anlægsmetoder, der kan overvejes for overbygningen, ved udførelse fra havet, såsom precast segmental, successiv fremskubning, og MSS-metoden, som beskrevet sidst i afsnittet.

Ved fuldfagsmontage installeres ét fag ad gangen. Fagene er præfabrikerede på (nærliggende) fabrikationsplads svarende til metoden benyttes til Storstrømsbroen. Eksempler af fuldfagsmontage er vist i Figur 8 til Figur 10.

Fuldfagsmontage vil for et 25 m fag resultere i en vægt på 6-700 tons og er derfor meget mindre end vægten for overbygning på Storstrømsbroen, hvor vægten er ca. 4000t. En mere sammenlignelig størrelse er vægten for Masnedsundbroen, der er vist i Figur 9. Produktionspladsen skal være indrettet så udrulning til en pram er muligt. For en bro med en bredde på 13 m kræves en uddybning ved i brolinjen samt ved siden af brolinjen på ca. 15 m og med en dybde på 3 m for at prammen kan komme til at montere brofagene.

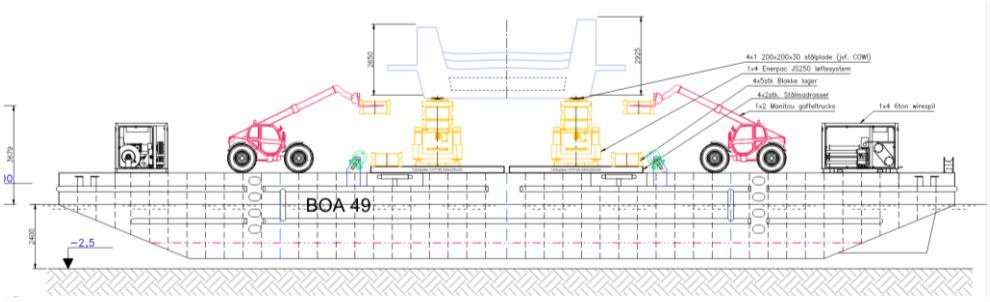
Ved fuldfagsmontage vil der være behov for et løftearrangement fra pram til niveauet for overbygningen.

Når først underbygningen er etableret, så kan overbygningens udførelse påbegyndes og kan forløbe stort set parallelt med udførelse af underbygningen.



Figur 8 *Storstrømsbroen, fuldfagsmontage.*

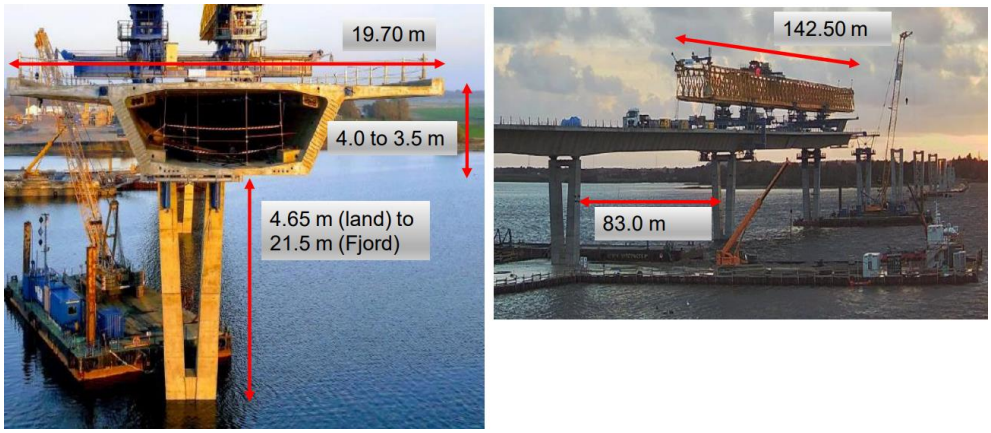
Figur 9 *Masnedsundbroen, fuldfagsmontage.*



Figur 10 *Udførelse af fuldt-fags montage i udgravet rende (eksempel fra Banedanmark projekt)*

Alternative udførelsesmetode

› **Precast segmental** vil for et 25 m fag typisk resultere i f.eks. at ét fag deles op i 8 segmenter, hver med en vægt på 60-80 tons. Segmenterne støbes på fabrik og sejles med pram til broen, hvor de monteres fagvist med en montagedrager. Det er mindre sandsynligt, at segmenterne støbes på en præfabrikationsplads tæt på vederlaget og transporteres på tidligere støbte fag til montagedrageren.



Figur 11 *Kronprinsse Marys Bro, precast segmental.*

› Broen kan støbes på land og monteres med **successiv fremskubning.** Anvendes successiv fremskubning (som f.eks. Funder Ådal for Vejdirektoratet) vil det være formålstjenligt at de 600 m bro er ét ekspansionsafsnit efter færdiggørelse. Alle materialer ifm. konstruktionen, på nær de permanente lejer, anvendes og indbygges på udførelsesstedet ved det østlige vederlag. Fremskubning udføres med montagenæse der typisk har en længde på ca. 80% af det første fag, altså f.eks. 80% * 25 m = 20 m. Det er med denne faglængde formentlig ret sandsynligt, at hvert støbeafsnit vil svare til en faglængde.

Figur 12 *Funder Ådal, successiv fremskubning med fremskubningsnæse til venstre.*

› In-situ støbt på flytbar forskallingsdrager **(MSS: Movable Scaffoldning System**). MSS-metoden består af en montagedrager, typisk i stål med form også i stål eller krydsfiner, og gør brug af, at alle materialer forud for in-situ støbning af hvert fag transporteres fra land via tidligere udførte fag til faget under udførelse. Anvendes MSS metoden med de meget moderate spændvidder, der er tilfældet for adgangsvejen til den fremskudte havn ved Tårs, vil det efter opnåelse af maksimal produktionshastighed, være muligt at færdiggøre mindst et fag per uge.

Figur 13 *Kayas Tyrkiet, MSS.*

For de ovennævnte tre alternative udførelsesmetoder gælder, at når først underbygningen er etableret, så kan overbygningens udførelse påbegyndes og kan forløbe stort set parallelt med udførelse af underbygningen.

4.1.3 Mængder og arealer

Det forventes, at der skal afgraves ca. 44.000 m³ moræneler i forbindelse med uddybning til renden med en bredde på 30 m og en dybde på 3 m. Det forudsættes, at moræneleret kan

sidelægges på havbunden inden den, fyldes tilbage i renden, når broen er etableret. Det kan dog blive nødvendigt at klappe noget af materialet.

Under forudsætning af sidelægning af det afgravede materiale vurderes det, at et areal på ca. 61.000 m² på havbunden vil blive berørt, inkl. renden og det sidelagte materiale.

4.2 Alternativ – Bro på lavt vand med udførelse fra land

Et alternativ til konstruktionsmetoderne beskrevet i afsnit 4.1, beskrives i det følgende og er baseret på udførelse af broen fra land. Der anlægges en midlertidig ca. 600m lang dæmning i hele broens længde med en bredde på ca. 25 meter og med en topkote på +2,0 - 2,5 m, afhængig af tidevands- og bølgedata samt risikovurdering af konsekvensen ved evt. overskyl i mere sjældne tilfælde.

Dæmningens bredde skal give en passagemulighed for materiel i broretningen ved siden af konstruktionerne i underbygningen – derfor betragtes en bredde på ca. 15 + 10 = 25 m. Når broen er etableret, kan det overvejes at benytte den midlertidige dæmning til at bygge vejdæmningen, så denne kan opbygges fra to fronter. Den midlertidige dæmning fjernes efter brug, materialet kan genbruges i vejdæmning og den fremskudte havn.

4.2.1 Underbygning

Fra den midlertidige dæmning udføres pæle (borede eller rammede), derefter støbes søjler.

Figur 14 Udførelse af borede pæle

4.2.2 Overbygning

Efterfølgende opsættes stillads til brodæk og brodækket støbes i en kontinuerlig proces, hvor antallet af fag i en støbning formentlig er begrænset til et enkelt fag og dermed maksimalt stillads for to fags længde. Genanvendelse af stillads og form forudses i så stort omfang det er praktisk muligt.

Figur 15 Bro efter afforskalling, understøttet på stillads

4.2.3 Mængder og arealer

Den midlertidige dæmning forudsættes opbygget af to ydre bunker af sprængstensfyld, hvor der efterfølgende opfyldes med sand mellem de to bunker. Det forventes, at der skal bruges ca. 40.000 m³ sprængstensfyld og mindre dæksten til midlertidig beskyttelse, samt ca. 55.000 m³ sand.

Den midlertidige dæmning vil dække et areal på ca. 30.000 m² på havbunden under anlægsfasen.

4.3 Bro på dybere vand

Udførelsen af denne strækning vil være afhængig af logistikken for dels den 600 m lange bro tættest på den eksisterende kyst og dels udførelsen af den ca. 2,1 km lange dæmningsstrækning.

Vanddybden er mindst 5 m og derfor er det nødvendigt, at der arbejdes fra havet for i hvert fald underbygningens vedkommende.

4.3.1 Underbygning

Broen kan enten funderes direkte på havbunden som undersøgt ifm. undersøgelsen af spændvidder i afsnit 2 eller funderes på pæle (borede eller rammede) med efterfølgende søjler og bjælker.

Alt arbejde vil skulle foregå med udstyr på pramme, se Figur 7 for princip.

4.3.2 Overbygning

Udførelsesmetoderne beskrevet i afsnit 4.1.2 er alle relevante.

Det skal i den forbindelse dog nævnes, at både metoden med fremskubning og MSS forudsætter adgang til de primære produktionssteder kan ske via den kystnære 600m lange bro og den 2,1 km lange dæmning. Det er nødvendigt for transport af materialer til overbygningen, der udføres in-situ.

Fuldfagsmontage er den mest sandsynlige metode, da vanddybden er tilstrækkelig og det giver fleksibilitet mht. produktionssted for brofagene. Desuden har denne metode ikke en direkte afhængighed af den kystnære bro og dæmning, idet montagen foregår helt og aldeles fra havet.

5 References

/1/ **DNV**
DNV-ST-0437 Loads and site conditions for wind turbines
2021.

/2/ **COWI**
A258774-HAV-RAP-03 Tårs-Konceptdesign af havn og dæmninger
2025.

Bilag A Parametre for moræneler

SUND OG BÆLT

UNDERSØGELSE AF FREMSKUDT FÆRGEHAVN VED TÅRS

PARAMETRE FOR MORÆNELER

ADDRESSE COWI A/S
Parallelvej 2
2800 Kongens Lyngby
Danmark

TLF +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.com

Geotekniske forhold

Det meget sparsomme geotekniske grundlag indeholder kun nogle få geologiske profiler og ingen geotekniske parametre. Tilgængelige geologiske data er inkluderet i Appendix A. De geologiske profiler viser primært moræneler fra havbundsniveau hvorfor parametre kun vurderes for moræneler ved hjælp af eksisterende COWI modeller.

Input parametre for de valgte modeller til bestemmelse af geotekniske parametre (Tabel 1) er poretal (e), plasticitetstindeks (I_P), rumvægt (γ) og forbelastingsspænding (σ'_{pc}). Til brug for indledende vurderinger er følgende parametre valgt på basis af de foreliggende data og generelt kendskab til moræneler:

- e=0.30
- I_P=10%
- γ/γ'=22/12kN/m³
- σ'_{pc}=900kPa.

Da in-situ spændingerne ($\sigma'_{vo}=z\gamma'$) varierer med dybden (z) vil styrke og stivheder ligeledes varier med dybden (se nedenstående figurer). Indledningsvist vurderes $E_{oed,sec}$ og c_u udfra $\sigma'_{vo}=\sigma'_{un}$l=100kPa og de effektive styrkeparametre φ' og c' udfra $\sigma'_3=\sigma'_{vo}$:

φ'=34° og c'=21kPa

c_u~275kPa

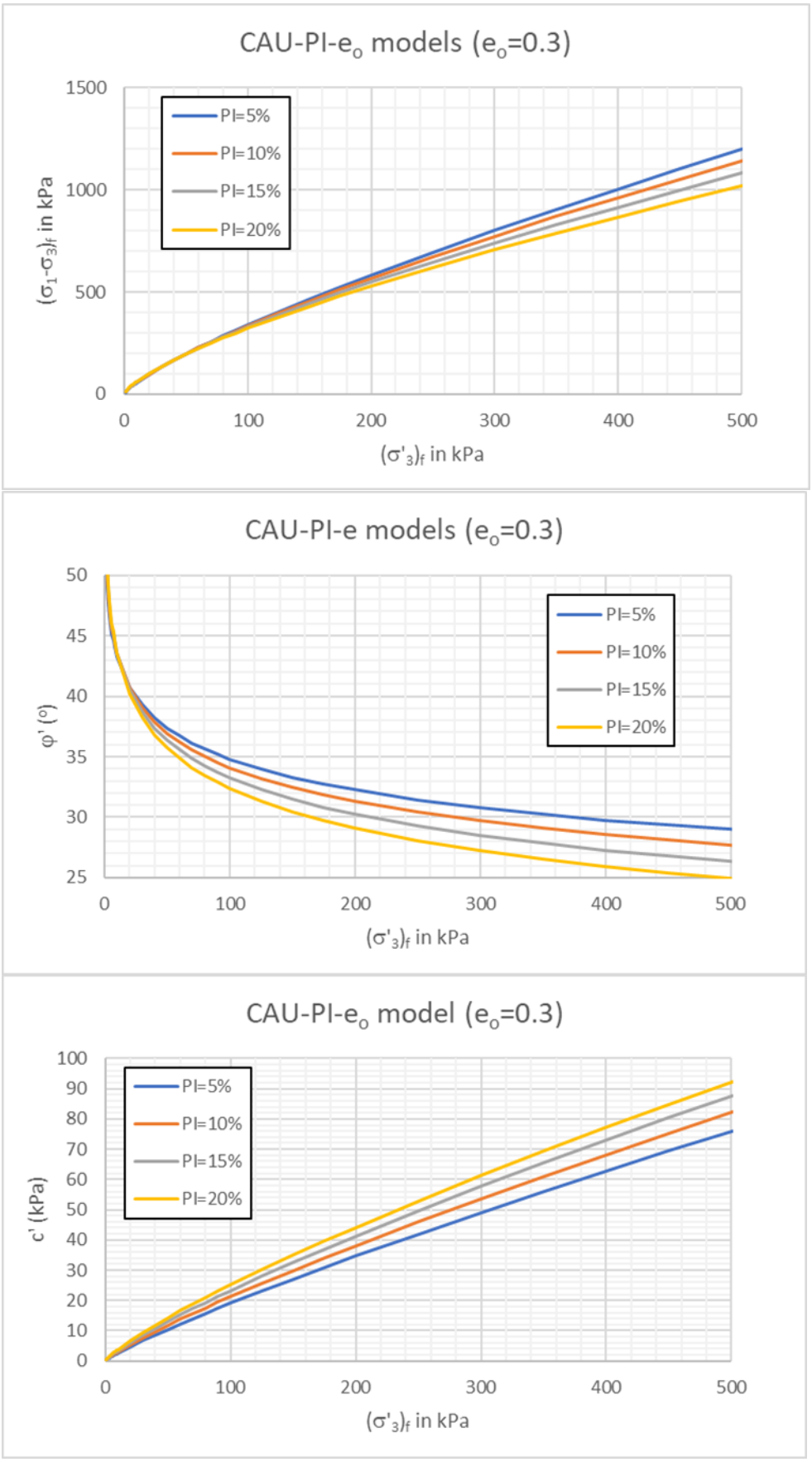
$E_{oed,sec}$~105MPa

PROJEKT NR.	DOCUMENT NR.
A258774	HAV-TEK-08

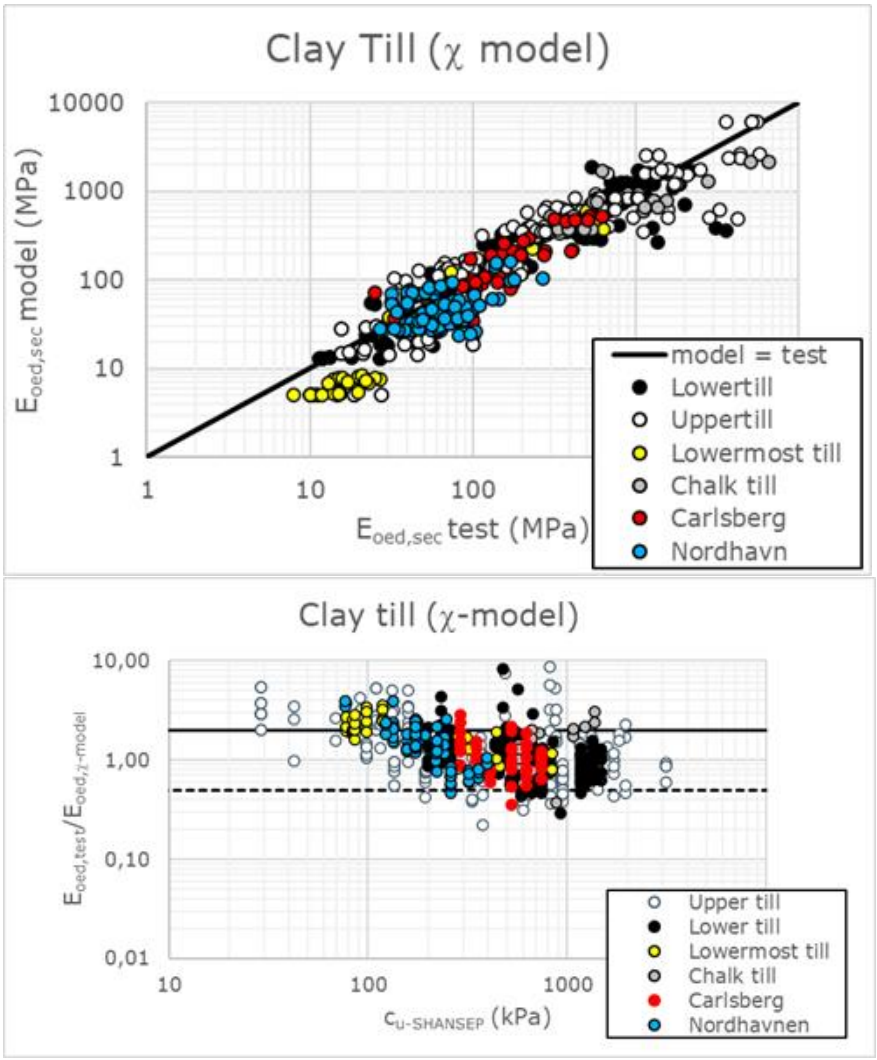
VERSION	UDGIVELSESDATO	BESKRIVELSE	UDARBEJDET	KONTROLLERET	GODKENT
1.0	08-11-2024	Parametre for moræneler	JESS	JJU	JJU

Tabel 1. Anvendte modeller for moræneler

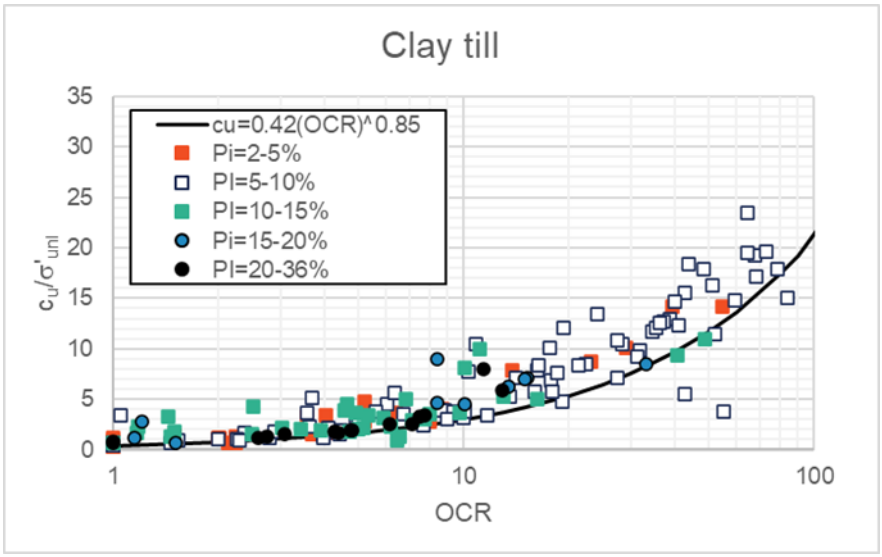
Parameter	Model	Bemærkning
Oedometer Modulus	$E_{oed,sec,\chi} \geq \left[10 + \chi \cdot \left(\frac{\sigma'_{pc}}{1kPa}\right)^{0.4} \cdot \left(\frac{\sigma'_{unl}}{\sigma'_{pc}}\right)^{\psi}\right] \sigma'_{pc}$ $\psi = 0.31 \cdot \left(\frac{I_p}{1\%}\right)^{0.44}$ I_P=5.5-60% $\chi = 45 + 0.0256\left(\frac{\Delta\sigma'}{1kPa}\right) \leq 55$	For c_u<150kPa bedre resultater opnås ved anvendelse af [ref.2] $E_{oed,sec} = 900\sigma'_v \left(\frac{c_u}{\sigma'_v}\right)^{0.375}$
Effektive styrkeparametre $(\sigma_1 - \sigma_3)_f = k_{1,CAU} \cdot \left(\frac{\sigma'_3}{1kPa}\right)^{k_2}$ $k_{1,CAU} = a_1 \cdot (e_o)^{-b_1}$ $k_2 = a_2 \cdot (e_o)^{b_2}$ $a_1 = 2.76675 + 0.053924 \cdot \frac{I_p}{1\%}$ $b_1 = 0.907 + 0.001620 \cdot \frac{I_p}{1\%}$ $a_2 = 0.8327 + 0.004004 \cdot \frac{I_p}{1\%}$ $b_2 = 0.02515 + 0.000816 \cdot \frac{I_p}{1\%}$	$\varphi' = arcsin\left(\frac{1}{1+2tan\beta}\right)$ $c' = a \cdot tan\beta \cdot tan\varphi$ $tan\beta = \frac{1}{k_1 k_2} \cdot \left(\frac{\sigma'_3}{1kPa}\right)^{1-k_2}$ $a = k_1 \cdot \left(\frac{\sigma'_3}{1kPa}\right)^{k_2} - \frac{\sigma'_3}{tan\beta}$	Baseret på krum brudkurve model [ref.1] CAU-PI-e_o
Udrænet forskydningsstyrke	$\frac{c_{u,CAU}}{\sigma'_v} = 0.42\left(\frac{\sigma'_{pc}}{\sigma'_v}\right)^{0.85}$ $c_u = \frac{q_{net}}{N_{kt}}$ $N_{kt} = \frac{1}{k_N \alpha} \cdot (OCR)^{1-\lambda}$ $\alpha = \left(\frac{c_u}{\sigma'_v}\right)_{NC}$=0.42	Baseret på "standard SHANSEP model" for moræneler, der synes at være en nedreværdi model [ref.2]



Figur 1. Krumme brudkurver for moræneler [ref.1].



Figur 2. Sekant oedometer modulus for moræneler [ref.2]



Figur 3. SHANSEP formel for moræneler [ref.2]

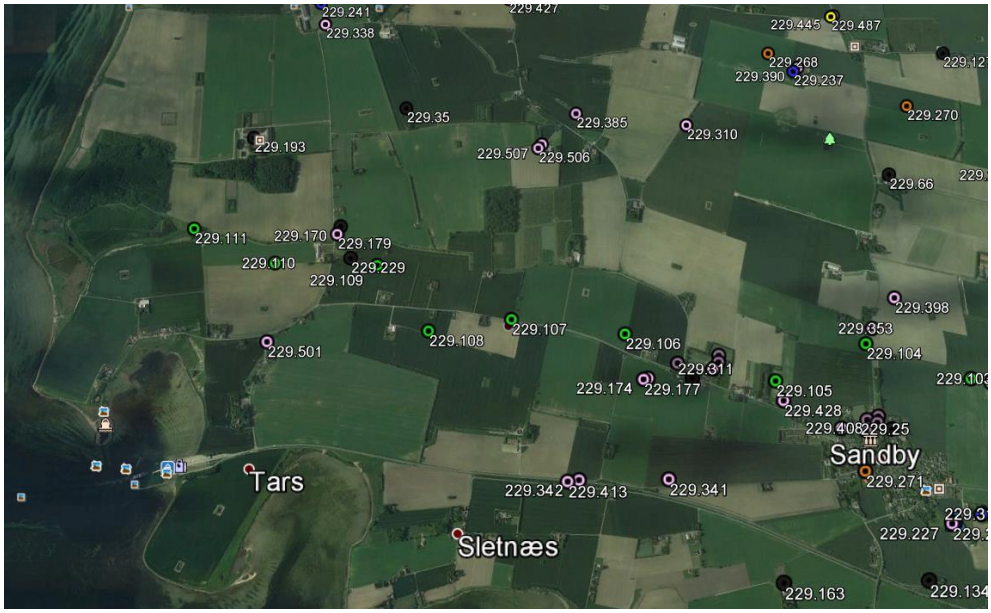
Referencer:

[1] Steensen-Bach, J.O., Steenfelt, J.S. & Hededal, O. (2024): *Effective strength parameters of Danish clay till – revisited*. Proceedings 18th ECSMGE Lisbon Portugal

[2] Steensen-Bach, J.O. (upubl.): *Reloading modulus of Danish clay till.* Planned for presentation at 21st ICSMGE 2026 in Vienna Austria.

Appendix A

I forbindelse med forundersøgelsen i 2018, blev jordbundsundersøgelser i området identificeret. I området på land er tidligere udført en række boringer registreret i GEUS (*De Nationale Geologiske Undersøgelser For Danmark og Grønland. National boringsdatabase (Jupiter)*). Disse boringer er placeret som vist på Figur A1.



Figur A1 *Boringer registreret i GEUS, på landsiden.*

Fra GEUS fremgår, at boringer også er udført i Storebælt på lokaliteter tæt på den fremskudte havn og tilslutningsvej på vand, se Figur A2.

Figur A2 *Boringer registreret i GEUS, på vandsiden.*

Tabel A1 angiver de registrerede aflejringer for de relevante boringer, 7 boringer på land og to boringer på vand. Det bemærkes, at der i alle landboringer træffes moræneler fra terræn til minimum 10,7 m under terræn. Boring 229.229 er udført til 46 m under terræn. Her er der konstateret moræneler til 37 m under terræn, herefter kalk.

Boringerne foretaget i Storebælt har begrænset dybde, kun op til 1 m. De viser, at der i overfladen er sand/silt/grus, hvorefter der træffes ler – forventeligt moræneler som på landsiden.

Tabel A1 GEUS data (simplificeret).

Boring	Placering	EUREF89 UTM32 N (m)	EUREF89 UTM32 E (m)	Dybde (mut)	Moræneler (mut)	Kalk (mut)	Sand
229.107	På land	632.026,002	6.083.707,116	13,7	0 – 13,7		
229.108	På land	631.572,005	6.083.638.118	13,7	0 – 13,7		
229.111	På land	630.239,012	6.084.283,116	10,7	0 - 10,7		
229.110	På land	630.711,01	6.084.061,116	13,7	0 – 13,7		
229.229	På land	631.133,007	6.084.091,115	46	0 – 37	37 - 46	
229.170	På land	631.070,007	6.084.297,113	45,5	0 – 35	35 – 45.5	
229.179	På land	631.052,008	6.084.247,114	52,6	0,5 – 18 20 - 32	32 – 52,6	0 – 0,5: muld 18 – 20: grus
541004.6	I Storebælt	625.933,034	6.084.292,127	1	0,5 - 1		0-0,5
541004.7	I Storebælt	625.092,039	6.083.768,135	0,9	0,4-0,9		0-0,2 0,2-0,4: Silt

Alle jordbundsundersøgelser viser forekomst af moræneler til stor dybde. Derfor forventes det, at en fremskudt færgehavn ved Tårs med tilhørende forbindelsesvej kan planlægges udført på stift, forkonsolideret moræneler.

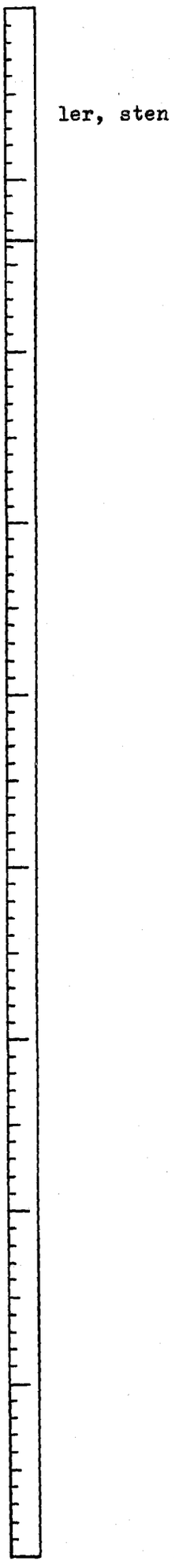
Arkiv-nr. 229.107

S A N D B Y

DAPCo profil LF-2 — boring nr. 79

udført 28.7.52.

Kote *m*



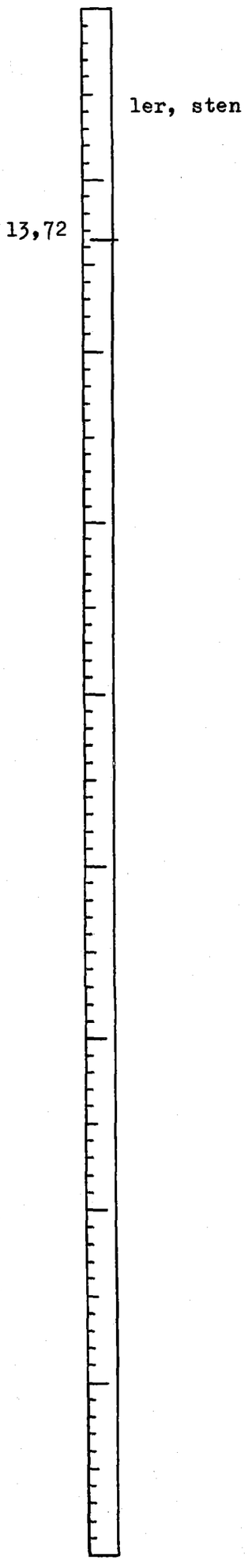
Arkiv-nr. 229.1o8

T A A R S

DAPCo profil LF-2 — boring nr. 8o

udført 28.9.52.

Kote *m*



Oa 09-10.

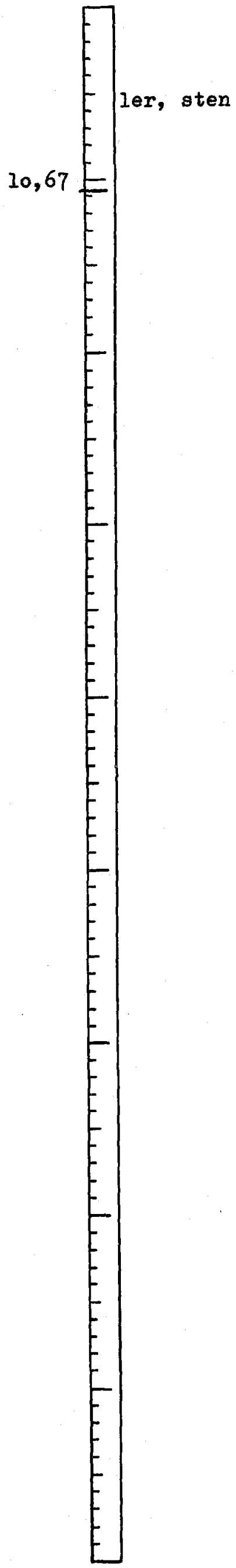
Arkiv-nr. 229.111

T A A R S

DAPCo profil LF-2 — boring nr. 83

udført 28.9.52.

Kote *m*



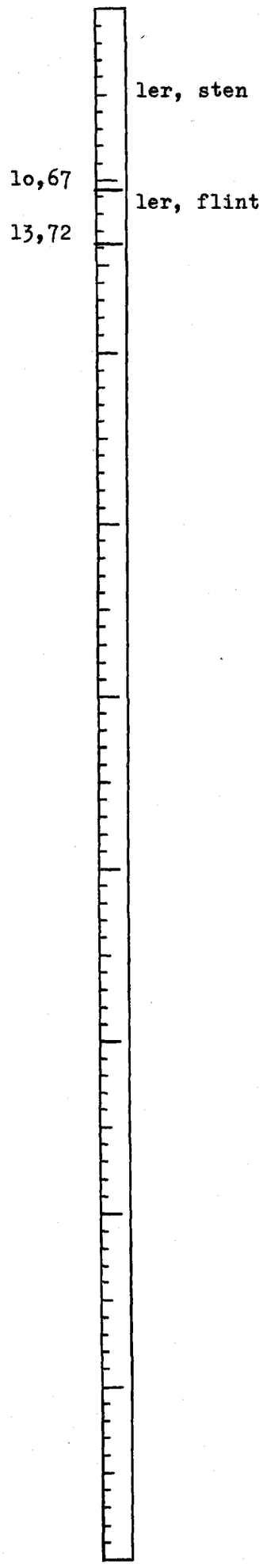
Arkiv-nr. 229.11o

T A A R S

DAPCo profil LF-2 — boring nr. 82

udført 28.9.52.

Kote *m*



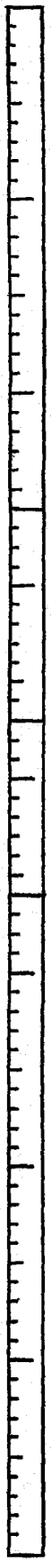
DGU
arkiv nr. 229. 229

TAARS

Gdr. Johannes Jørgensen, Skovstrade, Taarø — M 4320

Terrænkote	m	Sign.		Diameter	fra m	til m	Henry Eriksen, Hellinge
Opgivet			Bore-	76 mm	forerør		
Afl. på kort			rør				Inds. af H.Carstensen 27/5 1975
Afl. i terræn	4,5		Filter				Udført maj 1975
Nivelleret							Modt.

m. Prøver: Kornstørrelse efter NORGES GEOTEKNISKE INSTITUTTS skala



Kemisk analyse		Foraminiferanalyse		Antal prøver opbevaret	
Klorid mg/l		Sigteanalyse		Kasse nr.	
LVK-kendelse					

Os 09-68.

HARPELUNDE

Gedsejer Henkel, Stensgård, forvalterboligen, ca. 5oo m N fra hovedlandevejen Nakskov-Tårs, ad vej mod Stensg

gård og Frederiksdal
6" 45,5 m Forerør 165 mm o - 36,5 m

Kote ca +[illegible] *m*

Smedefirmaet Walther, Nakskov,
medd. d. 1/1o.1962,
udf. 13/8 - 8/9. 1962

Prøver:

Brønd	3,1			
Blåler				
	16,o	16,o m	Moræneler	sandet, lyst brunliggrå, gruset, stærkt l kalkholdigt
Blåler, mange sten				
		3o,o m	Moræneler	sandet, lyst brunliggrå, stærkt gruset, stærkt kalkholdigt
Blåler	33,o	33,o m	Meller	lysegrå, stærkt kalkholdigt, enk. hærdnede
	34,5			partier. Paleocæn Mergel
	35,5	35,o m	Forkislet Grønsandskalk	mørkegrå, grønligt, hårdt, kalkfrit, mang
Sandsten				nålformede Glaukonit-udfyldninger, en del
				Svovlkis
Kalk				
	45,5	45,5 m	Bryozokalk	gullighvid, løs, lidt gråbrun flint

Foraminiferanalyse i orig.

K. Højgård, det. 6/11. 1962

Vandrejsning 1,7 m under terræn

2 m^3/ t. ved 26,8 m sænkning

Pumpet i 16 timer

Vandspejlet retableret i løbet af 2 timer

Kloridindhold (under borearbejdet) før prøvepumpningen 14o mg/l
- - - efter - 14o mg/l

3 sidste prøver opbevaret.

Ks 947

TÅRS

D.G.U.'s boring ved Tårs

Udf. af Spang Nielsen udf. 1964
medd. d. 18/3. 1964

Kote *m*

Prøver:

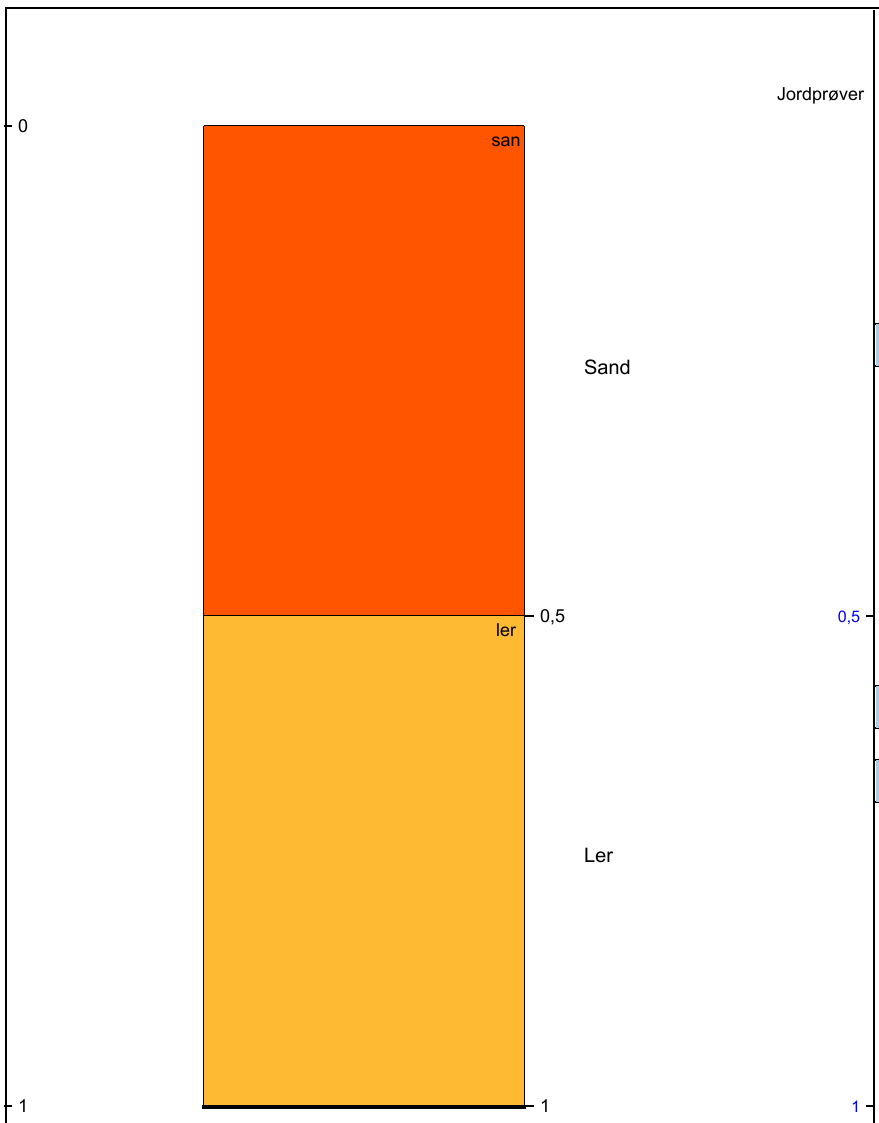
Muld	0,4			
Gult, sandet ler og sten og do. grå nederst gruset		1 – 18,0 m	Morænelер	finsandet, vekslende farver, nederst gruset og stærkt sandet, kalkholdigt
Grus og sten, nedefter meget stenet, enkl. lerklumper	18,0	18 – 20 m	Diluvialsand og -grus	usorteret og sten, grå, kalkholdigt
	20,4			
Grå, sandet, stenet ler fra 29,4 lidt blødere, men stadig stenet		21-32,4 m	Morænelер	finsandet, brungrå, kalkholdigt
		– 32,75 m	Finsandssten	tæt, hård, leret, grå-mørkgrå, svagt kalkholdig
mørkt dyndet ler	32,2			
Grå ler og grå hærdnede lag vekslende, nederst meget	32,4	– 34,80 m	Paleocæn Mergel	vekslende farver, kalkholdig
	34,8			
Kalk og flint				
		– 50,0 m	Bryozokalk	hvid – gullighvid, med mer og mindre flint
	52,6	– 52,6 m	Skrivekridt	slammet, blød, hvidlig, næsten flintfri

V. Krogh, det. 10 – 20/1. 1966
Udvidet prøvebeskrivelse i orig.

9/5. 1964 ved 51,30 m vandrejsning 6,10 m under terræn
Se yderligere i orig.

96 prøver opbevaret.

KS. 4444+45+46+47+48 kopieret.



G E U S

DGU-nr: 541004.6

Borerapport

Formål	: Råstofboring
Ejer	: GEUS
Borested	: Store Bælt
Placering	: UTM32 625933 6084292
Terrænkote	: DVR90
Lokalnummer	: 223-11-512021
Sagsnummer	
Boredato	
Brøndborer	: borearkiv

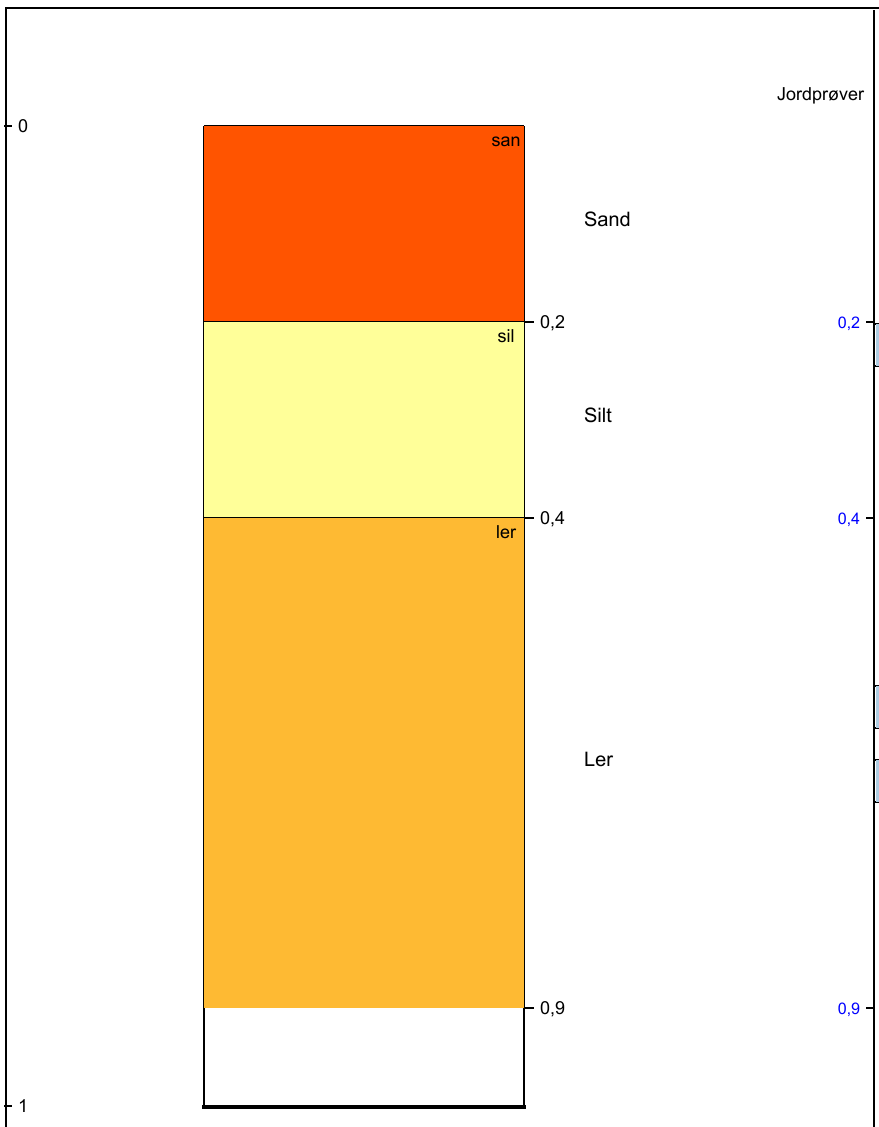
Boreteknik

Jordprøver

Jordprøver	: Udprintes ikke

GEUS

Adrese	: Øster Voldgade 10
By	: 1350 København K
Telefon	: 38142000
E-mail	: geus@geus.dk



G E U S

DGU-nr: 541004.7

Borerapport

Formål	: Råstofboring
Ejer	: GEUS
Borested	: Store Bælt
Placering	: UTM32 625092 6083768
Terrænkote	: DVR90
Lokalnummer	: 223-11-512022
Sagsnummer	
Boredato	
Brøndborer	: borearkiv

Boreteknik

Jordprøver

Jordprøver : Udprintes ikke

GEUS

Adrese	: Øster Voldgade 10
By	: 1350 København K
Telefon	: 38142000
E-mail	: geus@geus.dk

Bilag B Fundamentsberegning

ADRESSE COWI A/S
Parallelvej 2
2800 Kongens Lyngby

TLF +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.dk

UNDERSØGELSE AF FREMSKUDT HAVN VED TÅRS

FUNDAMENTSBEREGNING FOR BROER

INDHOLD

BILAG

1 Introduktion

I dette notat er funderingsløsningen af broer mellem fastlandet og den fremskudte færgehavn undersøgt. Broløsningerne er beskrevet i A25877-HAV-TEK-10, og det er vurderet at disse kan funderes direkte på moræneler.

Underbygningen består af 3 bropiller, der står på et betonfundament gravet ned i havbunden. Den geotekniske stabilitet af fundamenterne er undersøgt for forskellige spændvidder af betonbroens overbygning.

PROJEKTNR.	DOKUMENTNR.
A258774	HAV-TEK-09

VERSION	UDGIVELSESDATO	BESKRIVELSE	UDARBEJDET	KONTROLLERET	GODKENDT
1.0	21 januar 2025	Fundamentsberegning for bro	MCRO	JBGC	JJU

I denne indledende analyse er der set på egenvægtsbelastning, bevægelig last og vandrette belastning i form af bremsekræfter. Der er ikke set på påvirkninger fra skibsstød.

2 Forudsætninger

2.1 Geometri og laster

Fundamentets dimensioner er estimeret ud fra erfaringer med typiske lavbroer og som angivet i Tabel 2-1. Minimumslængden af fundamentet er 11 m grundet geometrien af overbygningen. På nuværende tidspunkt er underkanten af fundamenterne, FUK, ukendt hvorfor der konservativt regnes uden overlejringstryk.

Laster kommer også fra A258774-HAV-TEK-10 og er angivet i Tabel 2-1.

Tabel 2-1 Fundamenters geometri og laster

Spænd-vidde (m)	Funda-ments-bredde* (m)	Funda-ments-længde (m)	Funda-mentstyk-kelse (m)	Vertikal last (kN)	Moment (kNm)	Horisontal last (kN)
25	2,8	11,0	1,00	7608	2093	900
30	3,0	11,0	1,00	9128	2138	900
35	3,5	11,0	1,25	11047	2239	900
40	3,8	11,0	1,38	12675	2312	900
45	4,0	11,0	1,50	14383	2385	900
50	4,5	11,0	1,75	16659	2486	900
55	5,0	11,0	2,00	19094	2588	900

*Baseret på først estimat inden vurdering af indledende geotekniske parameter, se A258774-HAV-TEK-10

2.2 Geologi

Geologien og de geotekniske forhold er beskrevet i HAV-TEK-08. Broen vil blive funderet på moræneler med de i HAV-TEK-08 angivne parametre og opsummeret i Tabel 2-2.

Tabel 2-2 Parameter for moræneler

Jordtype	γ/γ' (kN/m³)	c_u (kPa)	ϕ' (°)	c' (kPa)	$E_{oed,sec}$ (MPa)
Moræneler	22/12	275	34	21	105

2.3 Sikkerhed og lastkombinationer

Bestemmelse af fundaments bæreevne er udført i henhold til DS/EN 1997-1 DK NA:2021 Tabel A.3-1 i konsekvensklasse 3 (CC3).

Fundamenterne er eftervist for både drænet og udrænet tilfælde.

3 Resultater

Beregningerne af fundamenternes bæreevnen er udført for alle spændvidder angivet i Tabel 2-1. Resultater for alle spændvidder er angivet i Bilag A, der også indeholder de detaljerede beregninger.

Resultater for en spændvidde på 25 m angivet i Tabel 3-1. Udnyttelsesgraden er 0,95 for det drænede tilfælde, og derfor er den estimerede fundamentsbredde på 2,8 m tilstrækkelig.

Tabel 3-1 Resultater for fundamentsberegning med en spændvidde på 25 m

Spændvidde	Tilfælde	Fundaments-bredde (m)	Bæreevne, R_d/A' (kN/m²)	Laster, V_d/A'	Udnyttelses-grad (-)
25	Udrænet	2,8	680	348	0,51
25	Drænet	2,8	368	348	0,95

Bilag A Fundamentsberegninger

Bæreevne for drænet tilfælde

Spænd-vidde (m)	Kon-struktions-højde (m)	Dia-meter søjler (m)	Funda-ments bredde [m]	Funda-ments tykkelse [m]	Funda-ments længde [m]	Normal kraft under funda-ment egen-vægt [kN]	Normal-kraft be-vægelig last [kN]	Moment fra langsgående vandret kraft (kNm)	Effektiv bredde af fundamen-ter [m]	Funda-ments tryk [kPa]	Jordens kapaci-tet [kPa]
25	1,1	0,80	2,8	1,00	11,0	5.489	2.119	2.093	1,99	348	368
30	1,3	0,90	3,0	1,00	11,0	6.765	2.363	2.138	2,37	350	397
35	1,5	1,00	3,5	1,25	11,0	8.440	2.606	2.239	2,97	338	433
40	1,7	1,00	3,8	1,38	11,0	9.825	2.850	2.312	3,28	351	454
45	1,9	1,10	4,0	1,50	11,0	11.290	3.094	2.385	3,58	366	473
50	2,1	1,20	4,5	1,75	11,0	13.322	3.338	2.486	4,13	367	501
55	2,3	1,30	5,0	2,00	11,0	15.512	3.581	2.588	4,67	372	527

Bæreevne for udrænet tilfælde

Spænd-vidde (m)	Kon-struktions-højde (m)	Dia-meter søjler (m)	Funda-ments bredde [m]	Funda-ments tykkelse [m]	Funda-ments længde [m]	Normal kraft under funda-ment egen-vægt [kN]	Normal-kraft be-vægelig last [kN]	Moment fra langsgående vandret kraft (kNm)	Effektiv bredde af fundamen-ter [m]	Funda-ments tryk [kPa]	Jordens kapaci-tet [kPa]
25	1,1	0,80	2,8	1,00	11,0	5.489	2.119	2.093	1,99	348	680
30	1,3	0,90	3,0	1,00	11,0	6.765	2.363	2.138	2,37	350	695
35	1,5	1,00	3,5	1,25	11,0	8.440	2.606	2.239	2,97	338	713
40	1,7	1,00	3,8	1,38	11,0	9.825	2.850	2.312	3,28	351	721
45	1,9	1,10	4,0	1,50	11,0	11.290	3.094	2.385	3,58	366	728
50	2,1	1,20	4,5	1,75	11,0	13.322	3.338	2.486	4,13	367	739
55	2,3	1,30	5,0	2,00	11,0	15.512	3.581	2.588	4,67	372	749

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	1

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

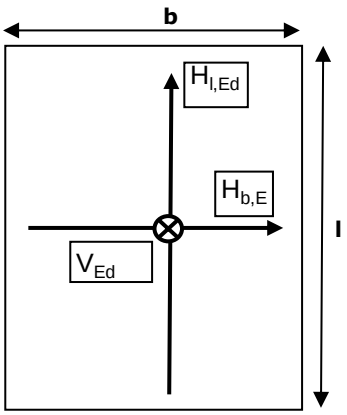
Vertical load in foundation level (FUK)	V_{Ed}	7608,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2093,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	2,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,28	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	1,99	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	21,86	m^2

Loads

Loads:



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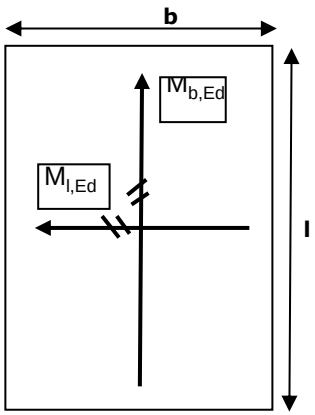


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs			**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span			**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	1

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,04	-
Inclination factor of the load	i_{co}	0,92	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	680	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**680**	**kN/m^2**
Design load	**V_d/A'**	**348**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,30 < 1,00	?
H_{Ed}/V_{Ed}	0,12 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,10
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	2

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

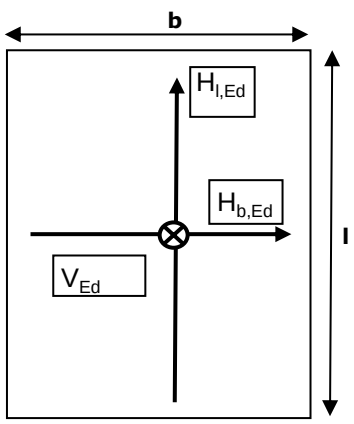
Vertical load in foundation level (FUK)	V_{Ed}	7608,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2093,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	2,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,28	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	1,99	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	21,86	m^2

Loads

Loads:



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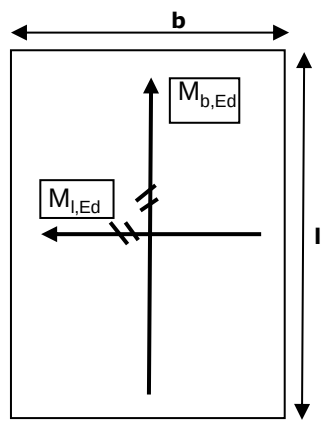


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	2

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,04	-
Shape factor	s_γ	0,93	-
Shape factor	s_c	1,04	-
Inclination factor of the load	i_q	0,79	-
Inclination factor of the load	i_γ	0,63	-
Inclination factor of the load	i_c	0,79	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	53	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	315	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**368**	**kN/m^2**
Design load	**V_d/A'**	**348**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,36 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,10
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	3

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

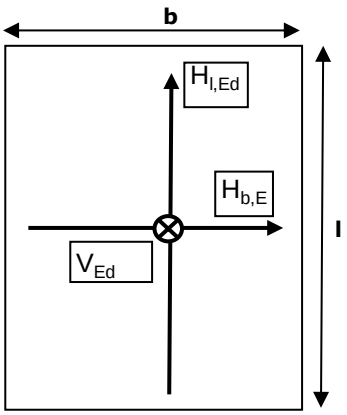
Vertical load in foundation level (FUK)	V_{Ed}	9128,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2138,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	3,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,23	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,37	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	26,05	m^2

Loads

Loads:



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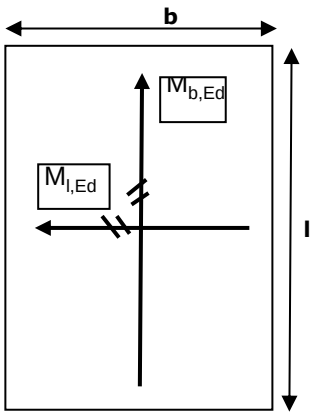


Design of spread foundations
Pad foundation on clay, undrained conditions
Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs			**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m span			**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	3

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,04	-
Inclination factor of the load	i_{co}	0,93	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	695	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**695**	**kN/m^2**
Design load	**V_d/A'**	**350**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,25 < 1,00 ?	
H_{Ed}/V_{Ed}	0,10 < 0,40 ?	

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,08
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m spand					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	4

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

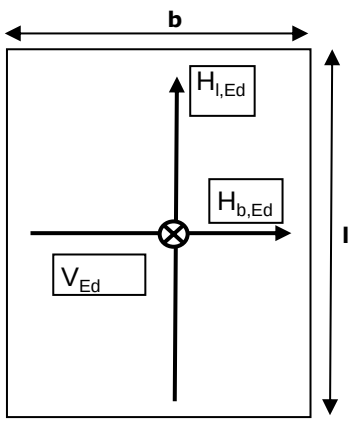
Vertical load in foundation level (FUK)	V_{Ed}	9128,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2138,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	3,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,23	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,37	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	26,05	m^2

Loads

Loads:



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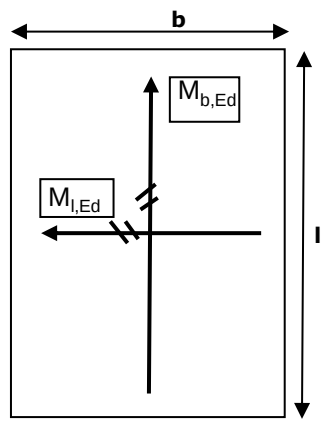


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m spand					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	4

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,04	-
Shape factor	s_γ	0,91	-
Shape factor	s_c	1,04	-
Inclination factor of the load	i_q	0,83	-
Inclination factor of the load	i_γ	0,68	-
Inclination factor of the load	i_c	0,83	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	67	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	330	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**397**	**kN/m^2**
Design load	**V_d/A'**	**350**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,30 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,08
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	5

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

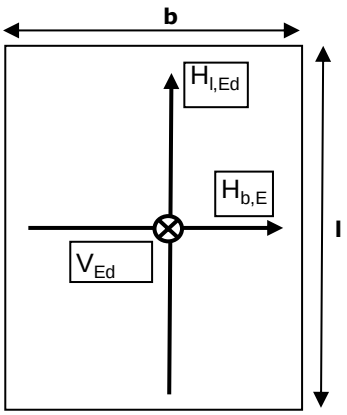
Vertical load in foundation level (FUK)	V_{Ed}	11046,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2239,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	3,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,20	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,97	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	32,66	m^2

Loads

Loads:



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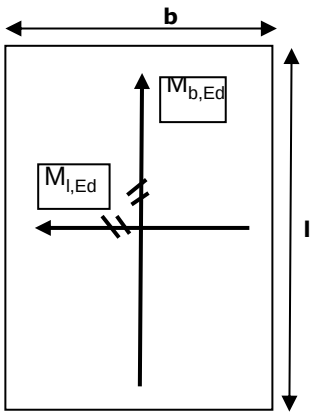


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	5

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,05	-
Inclination factor of the load	i_{co}	0,95	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	713	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**713**	**kN/m^2**
Design load	**V_d/A'**	**338**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,20 < 1,00 ?	
H_{Ed}/V_{Ed}	0,08 < 0,40 ?	

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,06
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	6

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

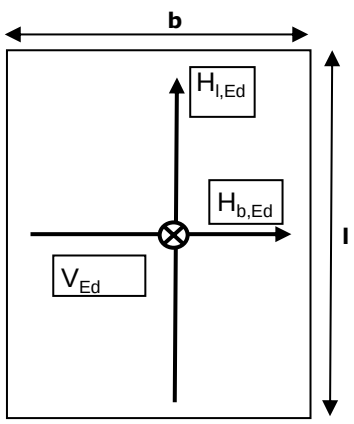
Vertical load in foundation level (FUK)	V_{Ed}	11046,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2239,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	3,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,20	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,97	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	32,66	m^2

Loads

Loads:



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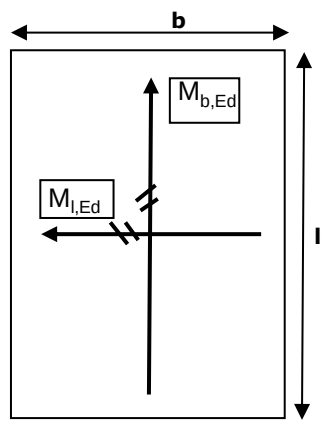


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	6

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,05	-
Shape factor	s_γ	0,89	-
Shape factor	s_c	1,05	-
Inclination factor of the load	i_q	0,86	-
Inclination factor of the load	i_γ	0,73	-
Inclination factor of the load	i_c	0,86	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	88	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	345	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**433**	**kN/m^2**
Design load	**V_d/A'**	**338**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,25 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,06
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	7

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

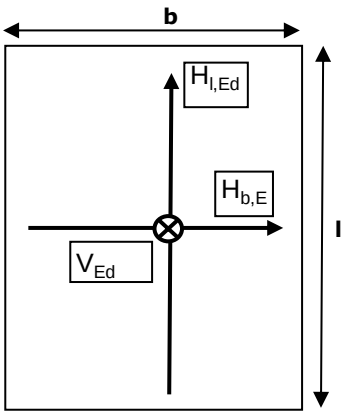
Vertical load in foundation level (FUK)	V_{Ed}	12675,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2312,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	3,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,18	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,28	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	36,07	m^2

Loads

Loads:



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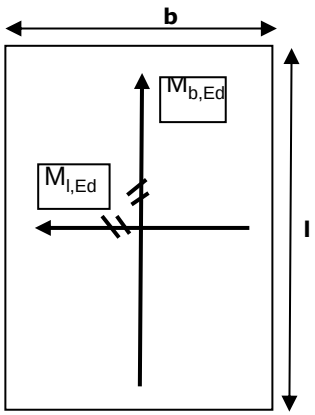


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	7

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,06	-
Inclination factor of the load	i_{co}	0,95	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	721	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**721**	**kN/m^2**
Design load	**V_d/A'**	**351**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,18 < 1,00	?
H_{Ed}/V_{Ed}	0,07 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,05
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	8

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

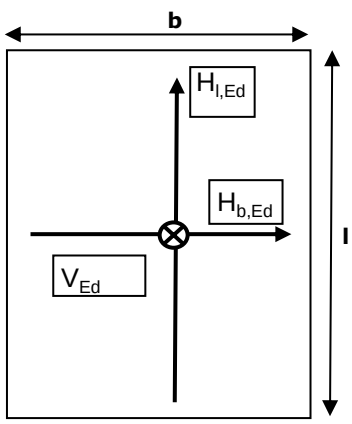
Vertical load in foundation level (FUK)	V_{Ed}	12675,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2312,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	3,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,18	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,28	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	36,07	m^2

Loads

Loads:



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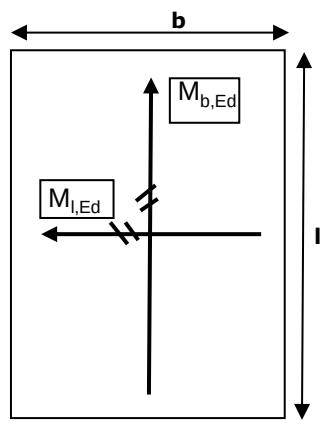


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	8

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,06	-
Shape factor	s_γ	0,88	-
Shape factor	s_c	1,06	-
Inclination factor of the load	i_q	0,87	-
Inclination factor of the load	i_γ	0,76	-
Inclination factor of the load	i_c	0,87	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	100	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	354	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**454**	**kN/m^2**
Design load	**V_d/A'**	**351**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,22 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,05
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	9

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

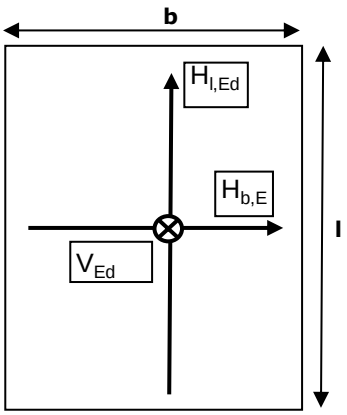
Vertical load in foundation level (FUK)	V_{Ed}	14384,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2385,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	4,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,17	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,58	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	39,35	m^2

Loads

Loads:



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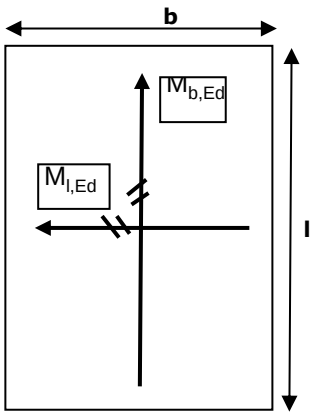


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	9

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,07	-
Inclination factor of the load	i_{co}	0,96	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	728	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**728**	**kN/m^2**
Design load	**V_d/A'**	**366**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,16 < 1,00	?
H_{Ed}/V_{Ed}	0,06 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,04
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	10

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

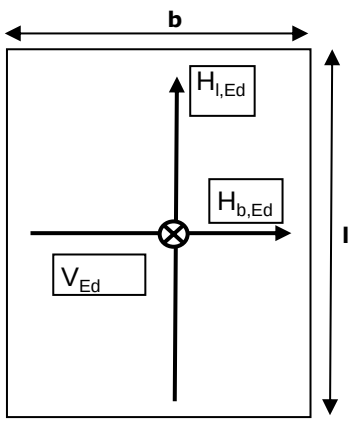
Vertical load in foundation level (FUK)	V_{Ed}	14384,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2385,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	4,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,17	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,58	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	39,35	m^2

Loads

Loads:



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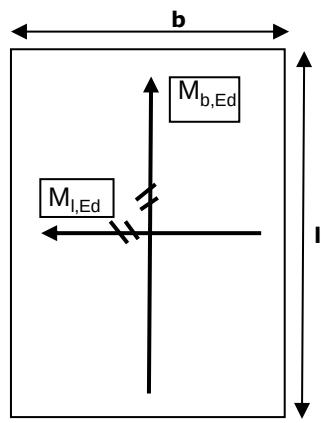


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	10

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,07	-
Shape factor	s_γ	0,87	-
Shape factor	s_c	1,07	-
Inclination factor of the load	i_q	0,89	-
Inclination factor of the load	i_γ	0,79	-
Inclination factor of the load	i_c	0,89	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	111	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	362	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**473**	**kN/m^2**
Design load	**V_d/A'**	**366**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,19 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,04
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	11

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

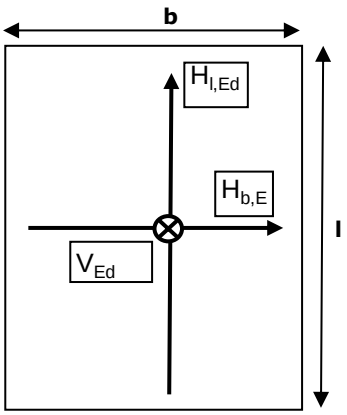
Vertical load in foundation level (FUK)	V_{Ed}	16660,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2486,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	4,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,15	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,13	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	45,39	m^2

Loads

Loads:



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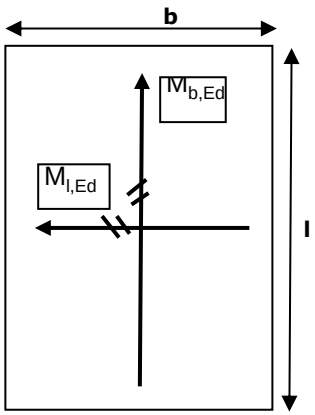


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	11

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,08	-
Inclination factor of the load	i_{co}	0,96	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	739	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**739**	**kN/m^2**
Design load	**V_d/A'**	**367**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,14 < 1,00	?
H_{Ed}/V_{Ed}	0,05 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,03
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

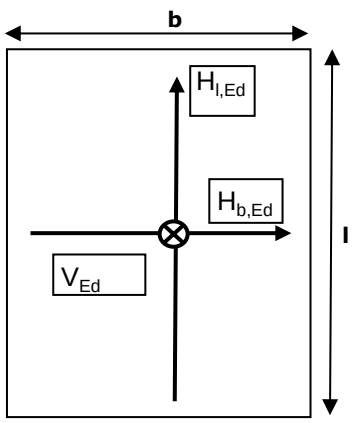
Vertical load in foundation level (FUK)	V_{Ed}	16660,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2486,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	4,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,15	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,13	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	45,39	m^2

Loads

Loads:



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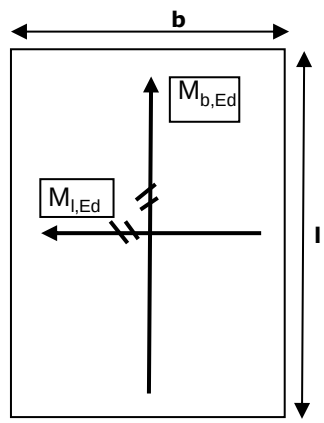


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,08	-
Shape factor	s_γ	0,85	-
Shape factor	s_c	1,08	-
Inclination factor of the load	i_q	0,90	-
Inclination factor of the load	i_γ	0,82	-
Inclination factor of the load	i_c	0,90	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	129	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	372	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**501**	**kN/m^2**
Design load	**V_d/A'**	**367**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,17 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,03
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	13

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

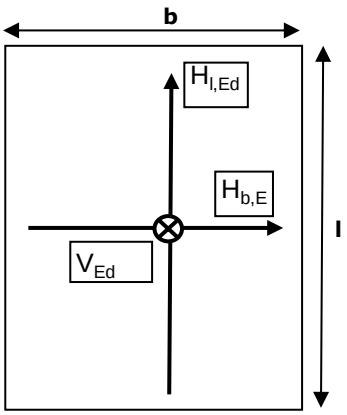
Vertical load in foundation level (FUK)	V_{Ed}	19093,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2588,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	5,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,14	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,67	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	51,33	m^2

Loads

Loads:



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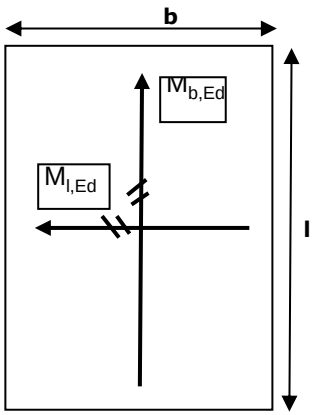


Design of spread foundations
Pad foundation on clay, undrained conditions
Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs			**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span			**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	13

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,08	-
Inclination factor of the load	i_{co}	0,97	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	749	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**749**	**kN/m^2**
Design load	**V_d/A'**	**372**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,13 < 1,00	?
H_{Ed}/V_{Ed}	0,05 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,03
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

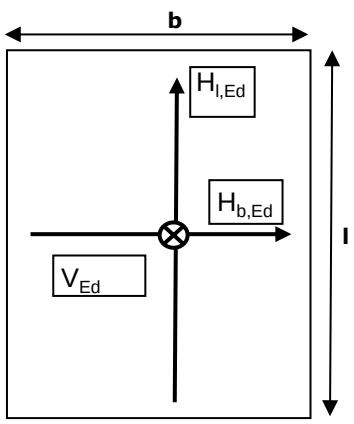
Vertical load in foundation level (FUK)	V_{Ed}	19093,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2588,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	5,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,14	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,67	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	51,33	m^2

Loads

Loads:



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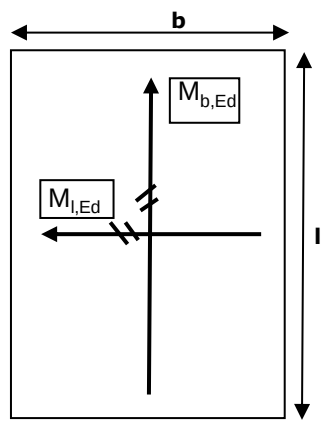


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,08	-
Shape factor	s_γ	0,83	-
Shape factor	s_c	1,08	-
Inclination factor of the load	i_q	0,91	-
Inclination factor of the load	i_γ	0,84	-
Inclination factor of the load	i_c	0,91	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	147	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	380	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**527**	**kN/m^2**
Design load	**V_d/A'**	**372**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,14 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,03
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	1

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

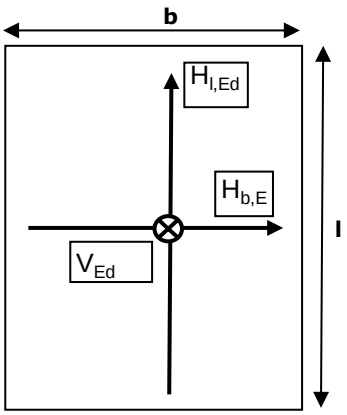
Vertical load in foundation level (FUK)	V_{Ed}	7608,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2093,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	2,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,28	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	1,99	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	21,86	m^2

Loads

Loads:



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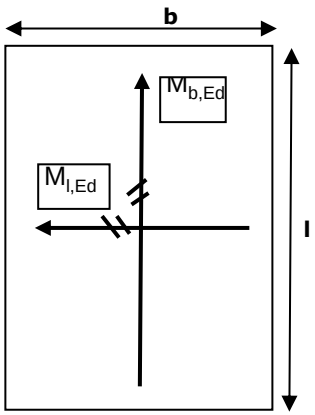


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs			**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span			**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	1

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,04	-
Inclination factor of the load	i_{co}	0,92	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	680	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**680**	**kN/m^2**
Design load	**V_d/A'**	**348**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,30 < 1,00	?
H_{Ed}/V_{Ed}	0,12 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,10
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	2

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

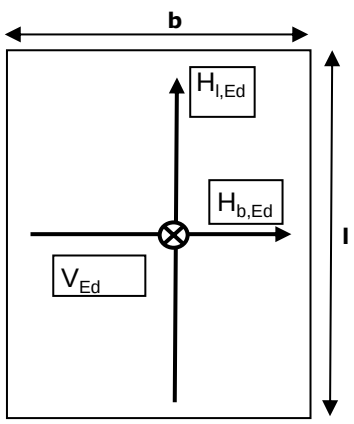
Vertical load in foundation level (FUK)	V_{Ed}	7608,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2093,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	2,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,28	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	1,99	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	21,86	m^2

Loads

Loads:



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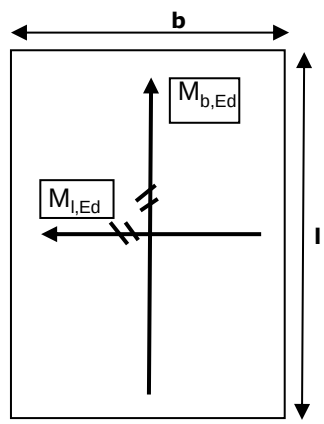


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 25 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	2

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,04	-
Shape factor	s_γ	0,93	-
Shape factor	s_c	1,04	-
Inclination factor of the load	i_q	0,79	-
Inclination factor of the load	i_γ	0,63	-
Inclination factor of the load	i_c	0,79	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	53	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	315	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**368**	**kN/m^2**
Design load	**V_d/A'**	**348**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,36 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,10
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	3

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

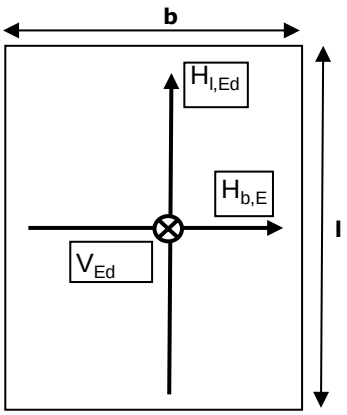
Vertical load in foundation level (FUK)	V_{Ed}	9128,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2138,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	3,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,23	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,37	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	26,05	m^2

Loads

Loads:



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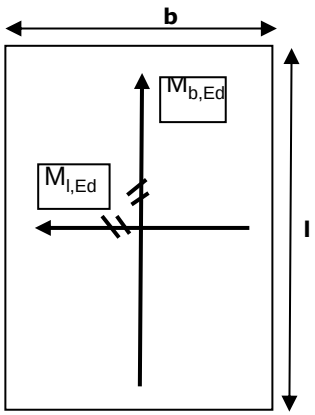


Design of spread foundations
Pad foundation on clay, undrained conditions
Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs			**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m span			**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	3

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,04	-
Inclination factor of the load	i_{co}	0,93	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	695	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**695**	**kN/m^2**
Design load	**V_d/A'**	**350**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,25 < 1,00 ?	
H_{Ed}/V_{Ed}	0,10 < 0,40 ?	

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,08
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m spand					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	4

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

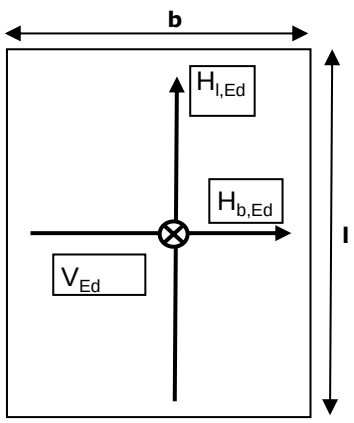
Vertical load in foundation level (FUK)	V_{Ed}	9128,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2138,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	3,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,23	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,37	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	26,05	m^2

Loads

Loads:



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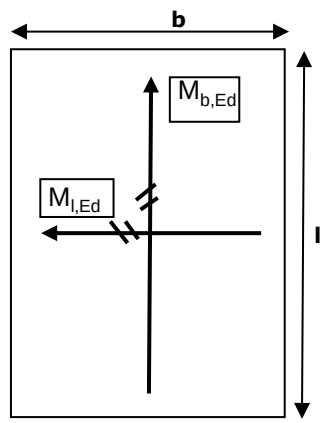


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 30 m spand					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	4

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,04	-
Shape factor	s_γ	0,91	-
Shape factor	s_c	1,04	-
Inclination factor of the load	i_q	0,83	-
Inclination factor of the load	i_γ	0,68	-
Inclination factor of the load	i_c	0,83	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	67	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	330	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**397**	**kN/m^2**
Design load	**V_d/A'**	**350**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,30 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,08
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	5

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

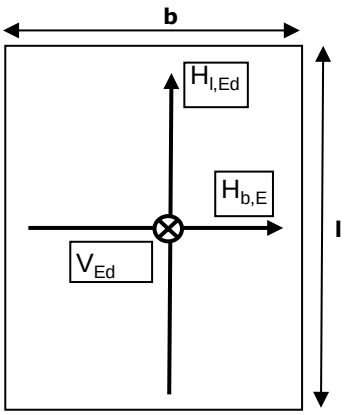
Vertical load in foundation level (FUK)	V_{Ed}	11046,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2239,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	3,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,20	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,97	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	32,66	m^2

Loads

Loads:



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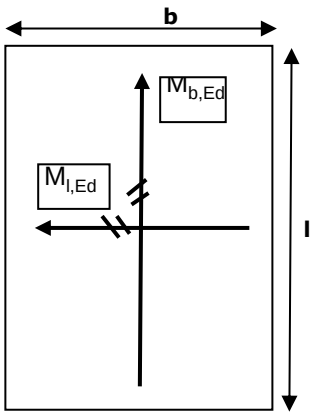


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	5

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,05	-
Inclination factor of the load	i_{co}	0,95	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	713	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**713**	**kN/m^2**
Design load	**V_d/A'**	**338**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,20 < 1,00 ?	
H_{Ed}/V_{Ed}	0,08 < 0,40 ?	

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,06
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	6

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

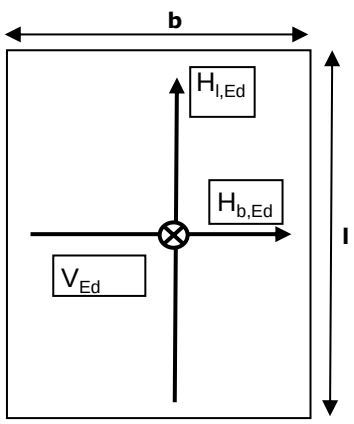
Vertical load in foundation level (FUK)	V_{Ed}	11046,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2239,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	3,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,20	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	2,97	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	32,66	m^2

Loads

Loads:



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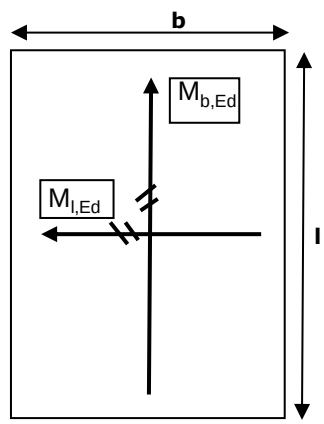


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 35 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	6

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,05	-
Shape factor	s_γ	0,89	-
Shape factor	s_c	1,05	-
Inclination factor of the load	i_q	0,86	-
Inclination factor of the load	i_γ	0,73	-
Inclination factor of the load	i_c	0,86	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	88	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	345	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**433**	**kN/m^2**
Design load	**V_d/A'**	**338**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,25 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,06
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	7

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

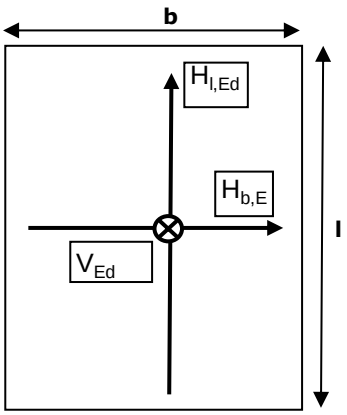
Vertical load in foundation level (FUK)	V_{Ed}	12675,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2312,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	3,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,18	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,28	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	36,07	m^2

Loads

Loads:



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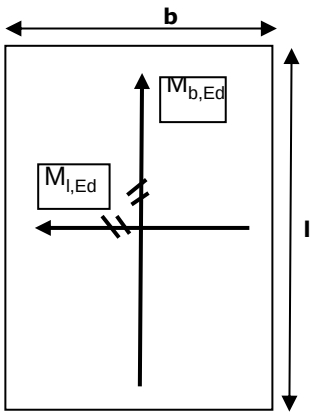


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	7

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,06	-
Inclination factor of the load	i_{co}	0,95	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	721	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**721**	**kN/m^2**
Design load	**V_d/A'**	**351**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,18 < 1,00	?
H_{Ed}/V_{Ed}	0,07 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,05
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	8

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

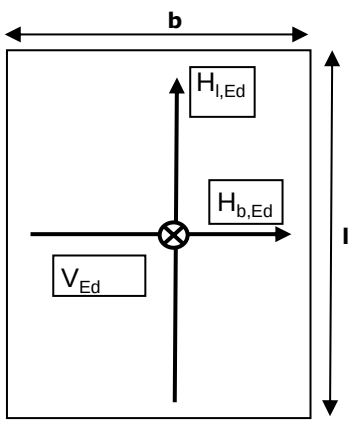
Vertical load in foundation level (FUK)	V_{Ed}	12675,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2312,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	3,75	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,18	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,28	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	36,07	m^2

Loads

Loads:



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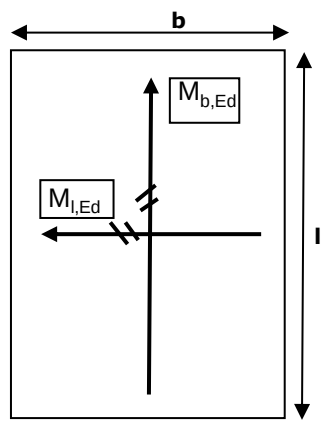


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 40 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	8

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,06	-
Shape factor	s_γ	0,88	-
Shape factor	s_c	1,06	-
Inclination factor of the load	i_q	0,87	-
Inclination factor of the load	i_γ	0,76	-
Inclination factor of the load	i_c	0,87	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	100	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	354	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**454**	**kN/m^2**
Design load	**V_d/A'**	**351**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,22 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,05
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	9

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

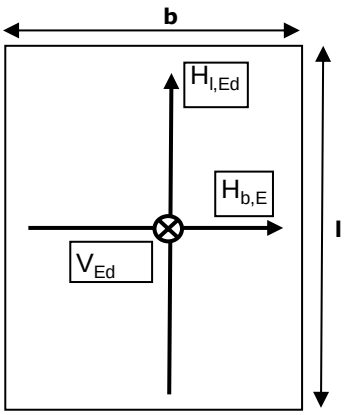
Vertical load in foundation level (FUK)	V_{Ed}	14384,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2385,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	4,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,17	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,58	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	39,35	m^2

Loads

Loads:



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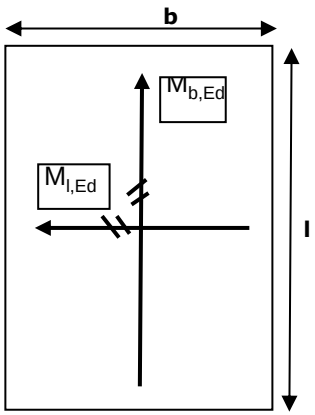


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	9

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,07	-
Inclination factor of the load	i_{co}	0,96	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	728	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**728**	**kN/m^2**
Design load	**V_d/A'**	**366**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,16 < 1,00	?
H_{Ed}/V_{Ed}	0,06 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,04
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	10

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

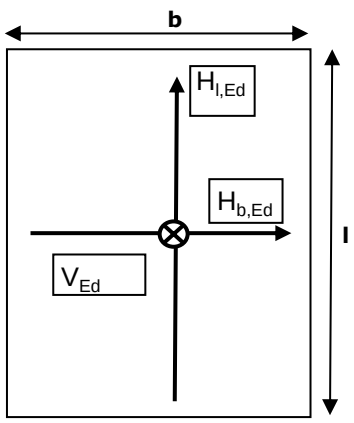
Vertical load in foundation level (FUK)	V_{Ed}	14384,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2385,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	4,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,17	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	3,58	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	39,35	m^2

Loads

Loads:



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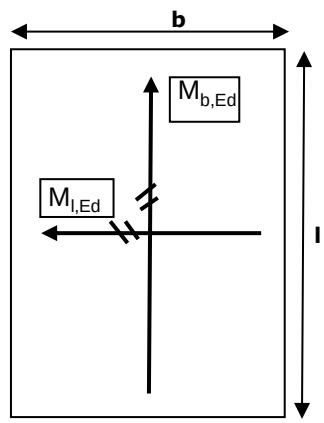


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 45 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	10

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,07	-
Shape factor	s_γ	0,87	-
Shape factor	s_c	1,07	-
Inclination factor of the load	i_q	0,89	-
Inclination factor of the load	i_γ	0,79	-
Inclination factor of the load	i_c	0,89	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	111	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	362	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**473**	**kN/m^2**
Design load	**V_d/A'**	**366**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,19 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,04
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	11

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

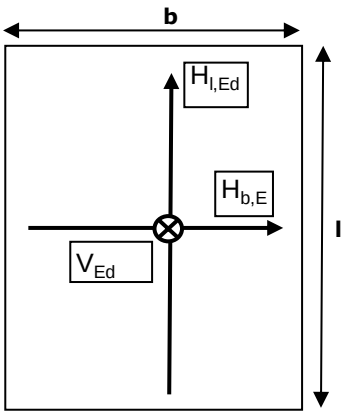
Vertical load in foundation level (FUK)	V_{Ed}	16660,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2486,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	4,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,15	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,13	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	45,39	m^2

Loads

Loads:



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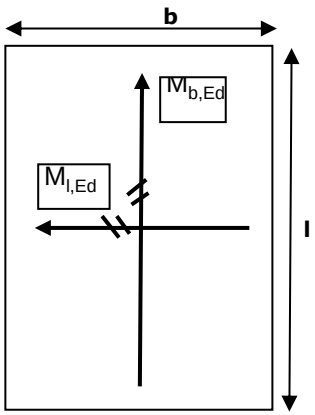


Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs	**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span	**Date:**	20-12-2024
Prepar.:	MCRO **Check:** JBGC **Approv.:** JJU	**Page:**	11

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,08	-
Inclination factor of the load	i_{co}	0,96	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	739	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**739**	**kN/m^2**
Design load	**V_d/A'**	**367**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,14 < 1,00	?
H_{Ed}/V_{Ed}	0,05 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,03
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

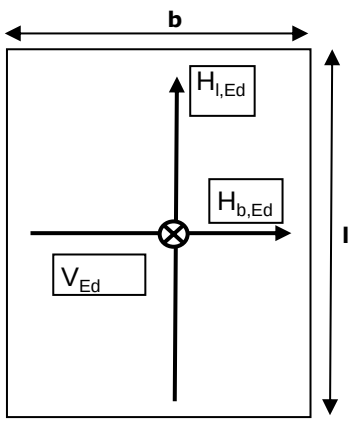
Vertical load in foundation level (FUK)	V_{Ed}	16660,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2486,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	4,50	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,15	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,13	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	45,39	m^2

Loads

Loads:



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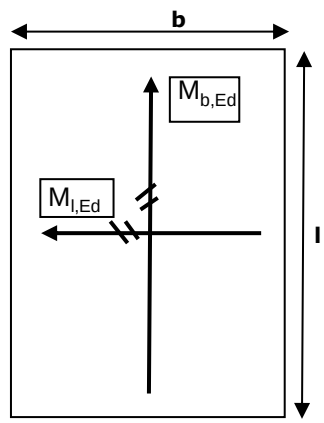


Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 50 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,08	-
Shape factor	s_γ	0,85	-
Shape factor	s_c	1,08	-
Inclination factor of the load	i_q	0,90	-
Inclination factor of the load	i_γ	0,82	-
Inclination factor of the load	i_c	0,90	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	129	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	372	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**501**	**kN/m^2**
Design load	**V_d/A'**	**367**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,17 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,03
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations
Pad foundation on clay, undrained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

COWI Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	13

INPUT

Soil parameters

Effective overburden pressure	q'	0,0	kN/m^2
Characteristic undrained shear strength	c_{uk}	275,0	kN/m^2
Partial factor	γ_{cu}	1,98	
Design value of undrained shear strength	c_{ud}	138,9	kN/m^2

Design loads

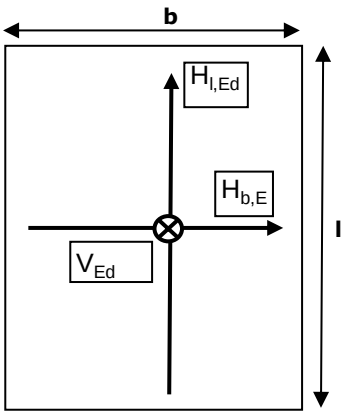
Vertical load in foundation level (FUK)	V_{Ed}	19093,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2588,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

Width of foundation	b	5,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,14	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,67	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	51,33	m^2

Loads

Loads:



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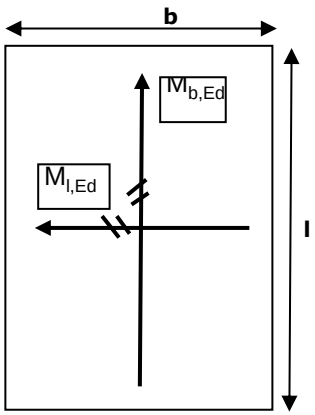

Design of spread foundations
Pad foundation on clay, undrained conditions
Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015. Ver. 2.

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Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs			**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span			**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	13

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_{co}	5,14	-
Shape factor	s_{co}	1,08	-
Inclination factor of the load	i_{co}	0,97	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	0	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	749	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**749**	**kN/m^2**
Design load	**V_d/A'**	**372**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

$H_{Ed}/(A'c_{ud})$	0,13 < 1,00	?
H_{Ed}/V_{Ed}	0,05 < 0,40	?

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

e_b/b	0,03
e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

INPUT

Soil parameters

Characteristic angle of shearing resistance	$\varphi'_{pl,k}$	34	deg.
Characteristic effective cohesion	$c_{k'}$	21	kN/m^2
Partial factor for angle of shearing resistance (tan phi)	γ_φ	1,32	
Partial coefficient for effective cohesion	$\gamma_{c'}$	1,32	
Design angle of shearing resistance	$\varphi'_{pl,d}$	27,1	deg.
Design effective cohesion	$c_{d'}$	15,9	kN/m^2
Effective weight density below the foundation level	γ'	10,0	kN/m^3
Effective overburden pressure	q'	0,0	kN/m^2

Design loads

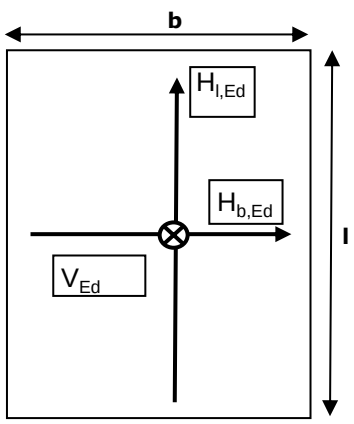
Vertical load in foundation level (FUK)	V_{Ed}	19093,0	kN
Binding moment around the longitudinale axis	$M_{b,Ed}$	2588,0	kNm
Horizontal load in the longitudinale axis	$H_{l,Ed}$	900,0	kN
Binding moment around the transverse (short) axis	$M_{l,Ed}$	0,0	kNm
Horizontal load in the transverse (short) axis	$H_{b,Ed}$	0,0	kN
Total horizontal load	H_{Ed}	900,0	kN

Dimension

It is a prefabricated foundation (set X) ?		X	
Width of foundation	b	5,00	m
Length of foundation	l	11,00	m
Eccentricity of design loads in transverse axis	e_b	0,14	m
Eccentricity of design loads in longitudinale axis	e_l	0,00	m
Effective width of foundation	b'	4,67	m
Effective length of foundation	l'	11,00	m
Effective area of foundation	A'	51,33	m^2

Loads

Loads:



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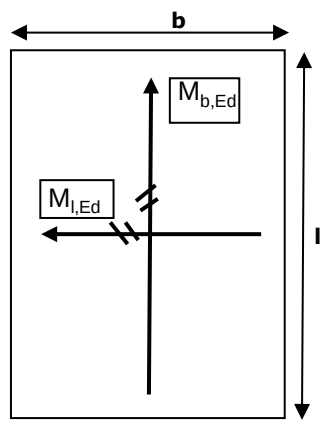

Design of spread foundations

Pad foundation on clay, drained conditions

Bearing resistance according to Eurocode 7, DS/EN 1997-1, 2. edition and DS/EN 1997-1 DK NA:2015.
Ver. 2.

COWI
Authorized Best Practice

Project:	Undersøgelse af fremskudt havn ved Tårs					**ATR.:**	A258774
Subject:	Bearing capacity of foundation - 55 m span					**Date:**	20-12-2024
Prepar.:	MCRO	**Check:**	JBGC	**Approv.:**	JJU	**Page:**	12

CALCULATION

Bearing capacity-, shape- and inclination factors

Bearing capacity factor	N_q	13,3	-
Bearing capacity factor	N_γ	9,1	-
Bearing capacity factor	N_c	24,1	-
Shape factor	s_q	1,08	-
Shape factor	s_γ	0,83	-
Shape factor	s_c	1,08	-
Inclination factor of the load	i_q	0,91	-
Inclination factor of the load	i_γ	0,84	-
Inclination factor of the load	i_c	0,91	-

Bearing resistance

Bearing resistance from overburden pressure	$R_{q,d}/A'$	0	kN/m^2
Bearing resistance from dead load	$R_{\gamma,d}/A'$	147	kN/m^2
Bearing resistance from cohesion	$R_{c,d}/A'$	380	kN/m^2
The total bearing resistance (design value)	**R_d/A'**	**527**	**kN/m^2**
Design load	**V_d/A'**	**372**	**kN/m^2**

Bearing resistance OK

Shear resistance (failure by sliding)

Cast on site: $H_{Ed}/(A'c_d'+V_{Ed}\tan(\varphi'_{pl,d}))$ 0,14 < 1,00 ?

Prefabricated: $H_{Ed}/(V_{Ed}\tan(2/3\varphi'_{pl,d}))$

Shear resistance (failure by sliding) OK

Estimation of eccentricity

If e/b > 0,3 a seperately calculation is required

	e_b/b	0,03
	e_l/l	0,00

CONCLUSION

Vertical bearing capacity:	**Bearing resistance OK**
Horizontal bearing capacity:	**Shear resistance (failure by sliding) OK**
Bearing capacity when eccentric loaded foundation:	**Seperate calculation NOT required**