

# Research at BU – Civil Engineering



## Research in Coastal and Ocean Engineering



# Wind Energy



150<sup>TH</sup>  
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**World's first university campus, running entirely on wind energy**



# Wave Energy: Smart Breakwater (PhD Thesis)



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## Submerged Heaving and Pitching Flat Plate - Combined Wave Attenuation and WEC

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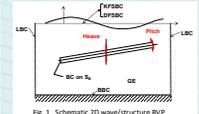
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### Introduction

Nearshore installation of wave energy converters (WEC) in moderate wave climates reduces the risk of high-energy events [1] and integrating WECs in coastal protection structures leads to shared costs [2]. In our study, active wave attenuation by a heaving and pitching submerged flat plate (SFP) is proposed. SFPs are environmental-friendly, cost- and time-efficient means of coastal protection and with the introduction of two degrees of freedom (heave and pitch) they become potential WEC devices.

### Method

The research is conducted numerically by applying the method of fundamental solution (MFS) using radial-basis-function collocation under the assumption of linear wave theory for monochromatic waves [3]. Fig. 1 shows the schematic setup of the 2D vertical boundary value problem. Plate heave and pitch motion are prescribed; the motion frequency equals the incidence wave frequency to mirror wave-forced motion.



### Conclusions

Combining coastal protection with wave energy harvesting offers several advantages: (1) one structure serves two purposes and (2) construction and maintenance costs are shared. Focusing on small scale WEC and shorter waves might provide the cheapest and most reliable power [6], p.2073. The heaving and pitching SFP could be a viable solution for Asian countries where medium wave conditions prevail. It offers an environmental friendly alternative to coastal protection with bottom-mounted breakwaters.

### References

- [1] A. Pecher and J.P. Robert, Handbook of Ocean Wave Energy, Ocean Engineering & Oceanography, 2020, Springer International Publishing AG, Switzerland.
- [2] M.A. Andrade et al., Wave energy device and breakwater integration: A review, Renewable and Sustainable Energy Reviews, 2017, 77, p. 4534.
- [3] A. Mueller, Active Wave Attenuation by a Submerged Heaving and Pitching Flat Plate, M.Sc. Thesis, Department of Civil Engineering, Boğaziçi University, Istanbul, Turkey, 2018.
- [4] J.M. Taylor, Clinging towers and the power spectrum of ocean waves, Philosophical Transactions of the Royal Society A, 2012, 370, p. 202-204.

### Results

The primary goal of the study was maximizing the wave attenuation for coastal protection. By adapting the plate submergence and inclination, and controlling the motion to ensure destructive interference between scattered and radiated wave on the transmission (lee) side of the plate, the wave attenuation of the moving SFP was improved and the frequency bandwidth of good wave attenuation was widened compared to the stationary SFP as shown in Fig. 2.

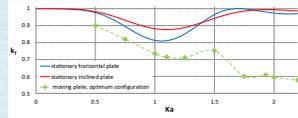


Fig. 2 Transmission coefficient for submerged plate with  $h/L=1/4$  and  $d/h=1/3$

In addition, the configurations, that yielded small transmission coefficients, coincided with energy flux of up to 30% out of the modelled system (Fig. 3). Integrated PFDs (e.g. pressurized hydraulic systems or motion resistance by a linear electrical motor [3]) could harness this power by utilizing the translation (heave) and rotation (pitch) of the SFP.

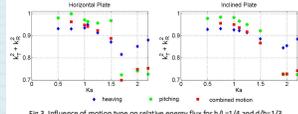
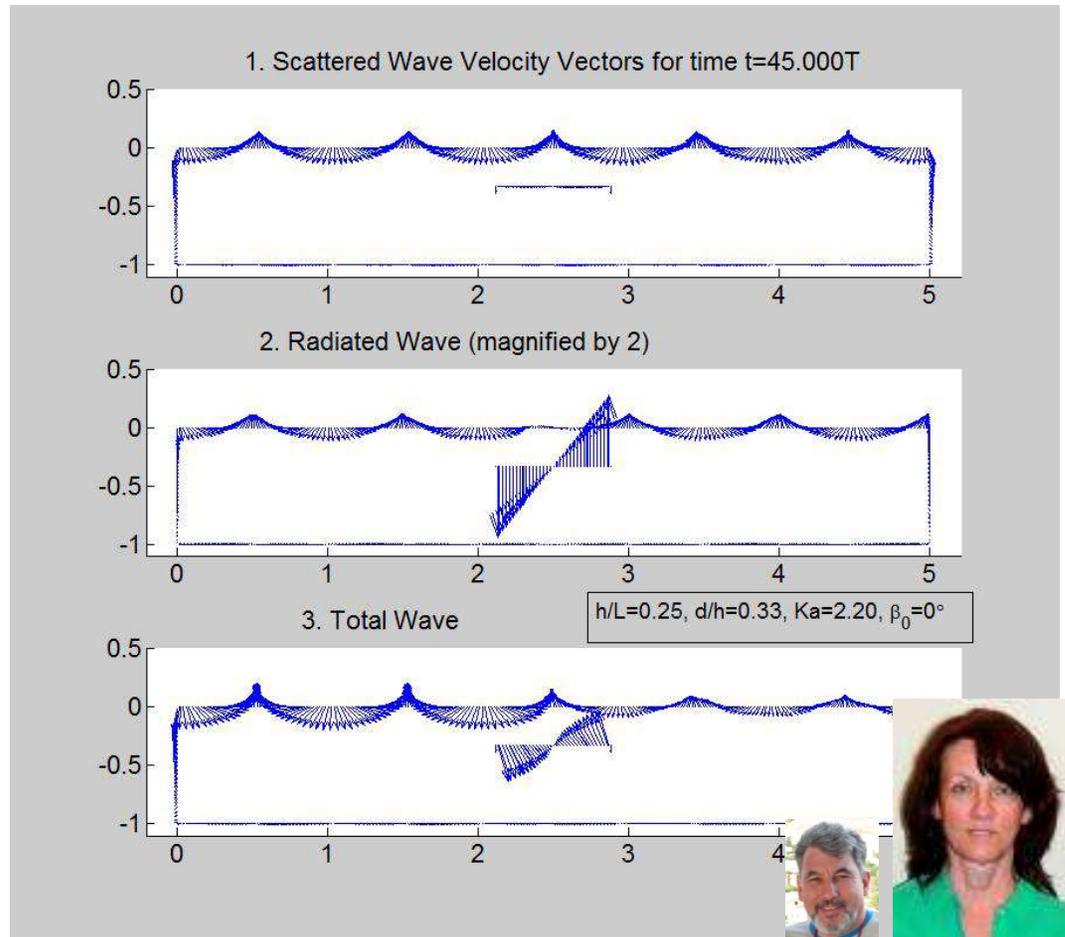
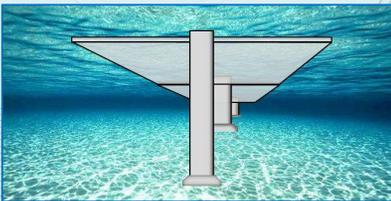


Fig. 3 Influence of motion type on relative energy flux for  $h/L=1/4$  and  $d/h=1/3$

Current plate size limitations will allow the application of the heaving and pitching SFP for wave periods up to 6s. This means that heaving and pitching SFPs can combine coastal protection with wave energy harnessing in moderate wave climates and small scale WEC.

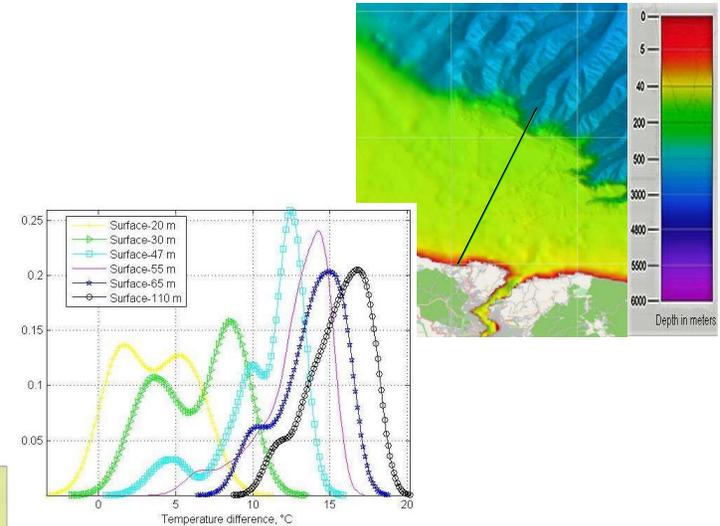
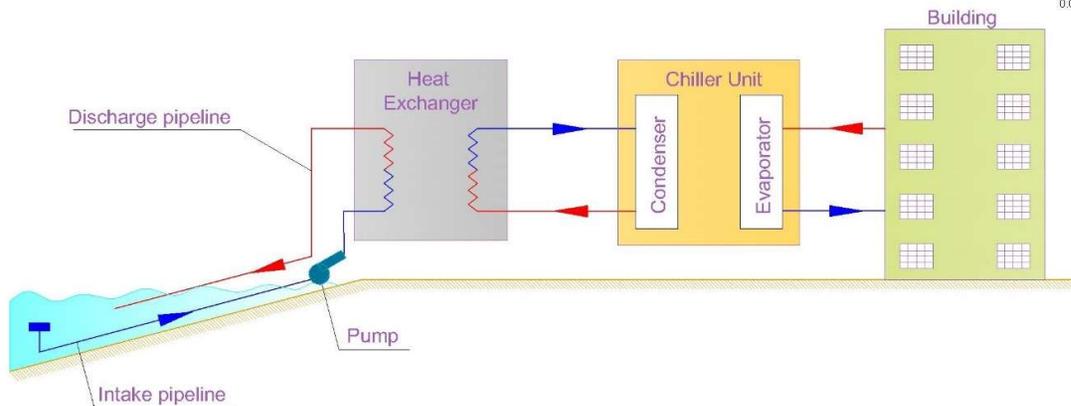


# Green Infrastructures: Ocean Thermal Energy-Seawater Airconditioning (MS Thesis)



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- ❖ Sea water intake and discharge
- ❖ Cold Intermediate Layer in BS
- ❖ Heat exchanger / chiller systems for air conditioning of campus buildings

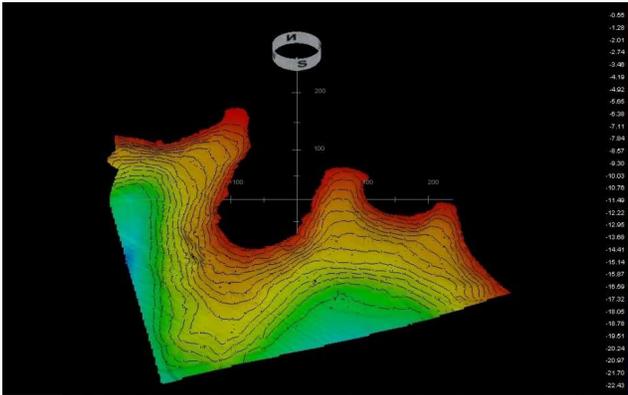




# Green Infrastructures: Coastal Protection with Soft Structures - Beach Nourishment



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Use of marine sand against coastal erosion



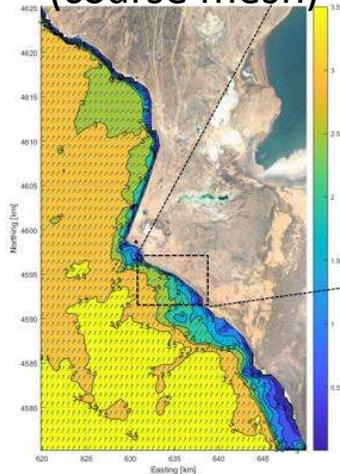
# Caspian Sea Intake/Outfall Analysis (sponsored by Gap Construction & Mitsubishi Heavy Industries)



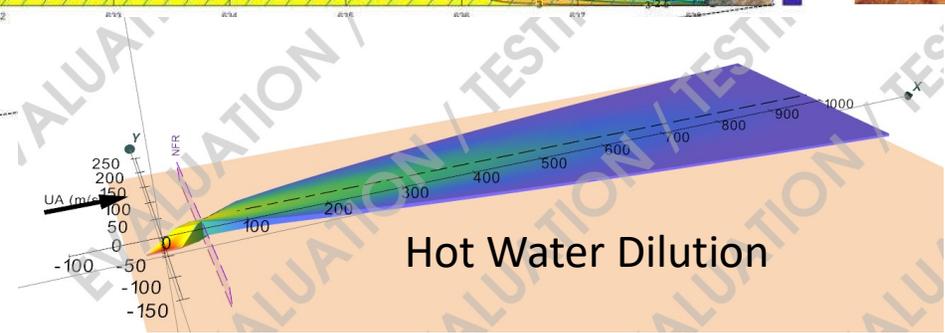
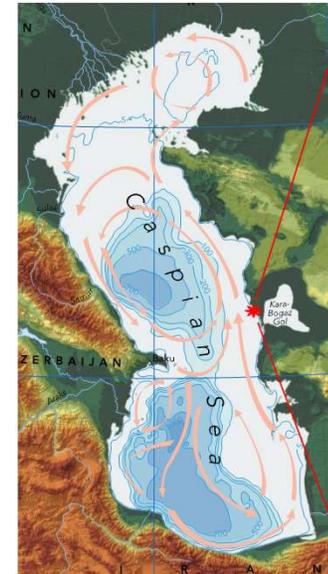
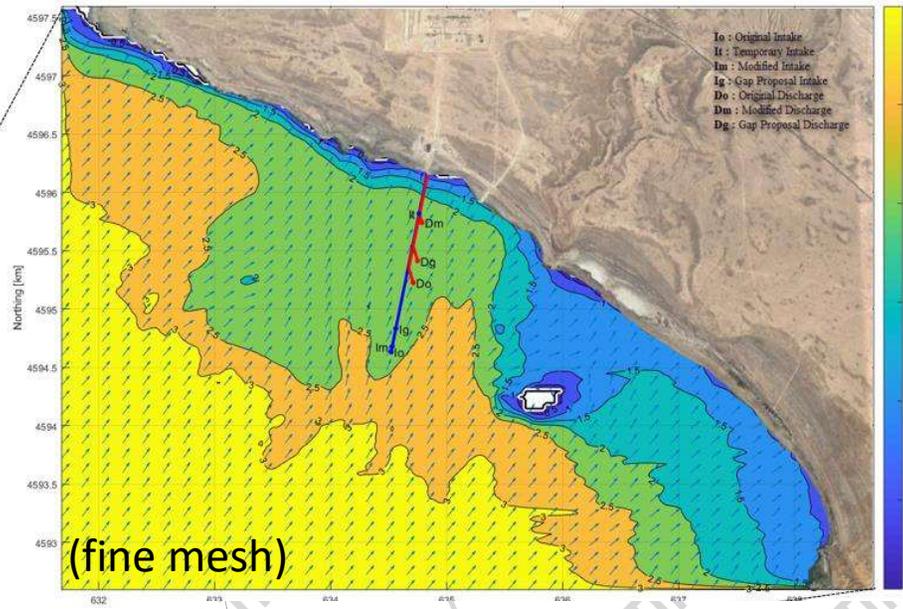
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Wave Agitation Analysis

(coarse mesh)



(fine mesh)

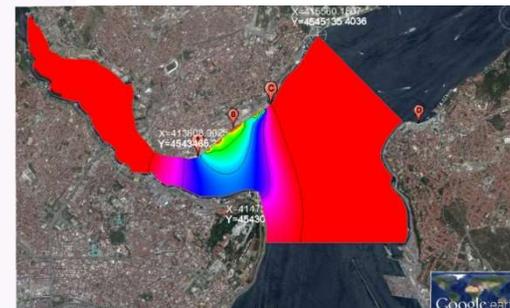
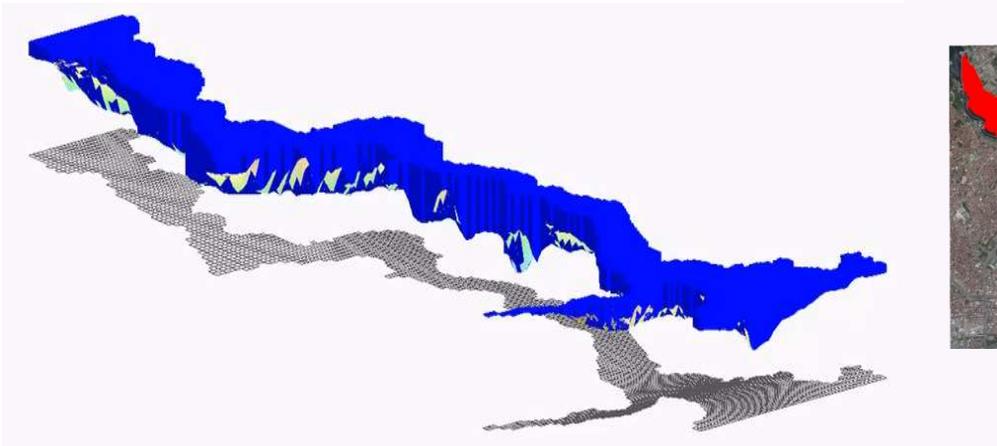
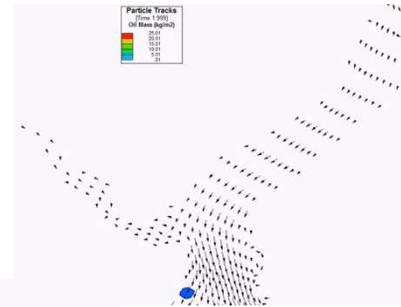
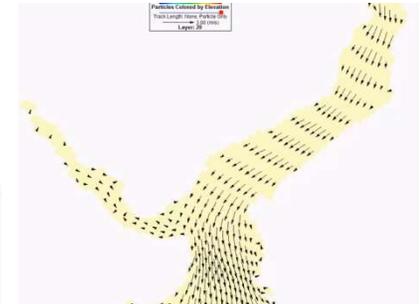


# Marine Contamination: Strait of Istanbul and Golden Horn (sponsored by GalataPort)



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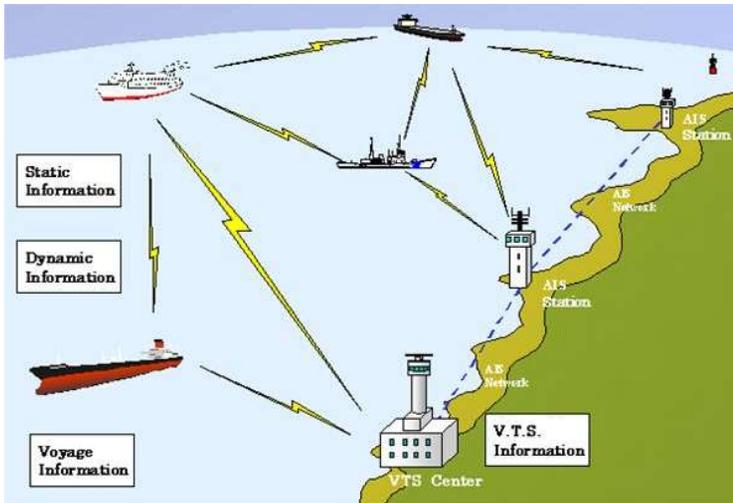
- ❖ 3D numerical model of water currents, temperature, salinity and contaminant transport
- ❖ Contamination of Golden Horn and the historic peninsula due to potential oil spills.



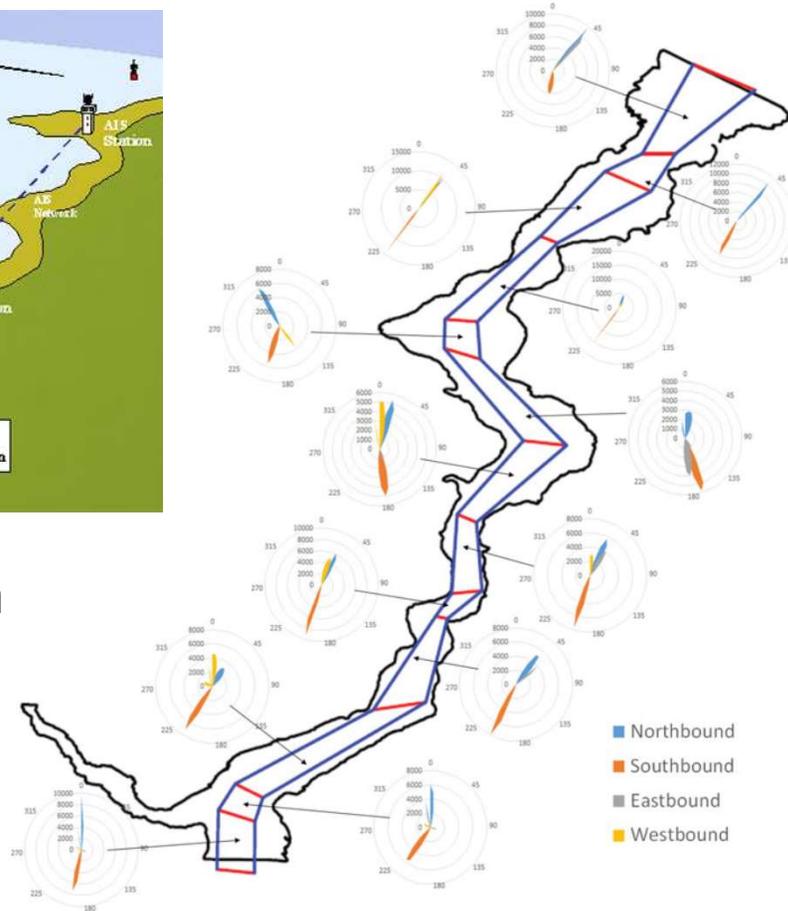
# Marine Contamination: Ship Tracking and Risk Mapping (PhD Thesis)



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Vessel tracking system recorded 1.5 billion AIS messages from 300.000 ships in 1 yr.



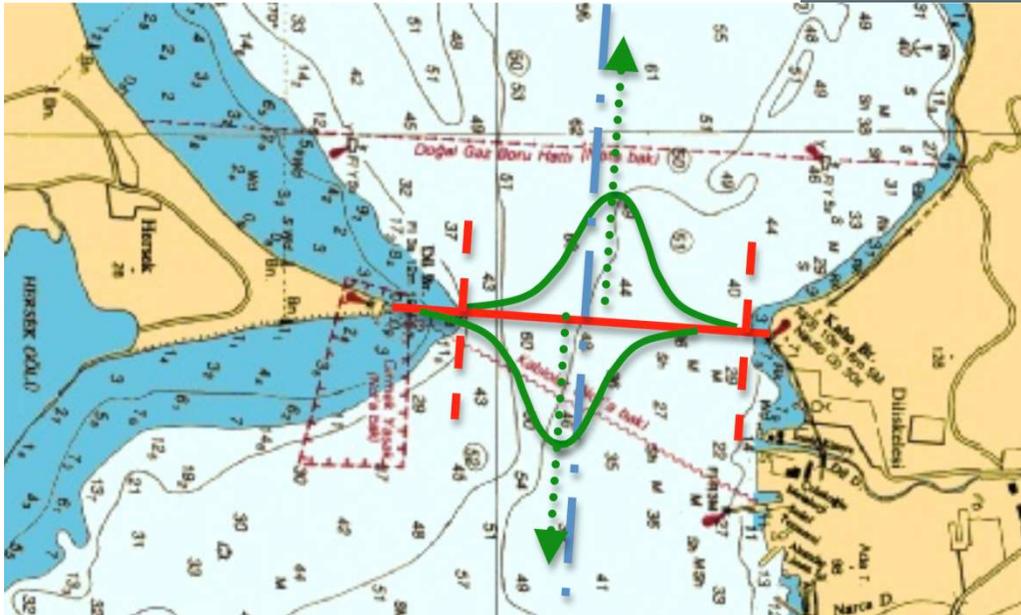
Directional Probability Distribution of Course Over Ground (COG)



# Osman Gazi Bridge - Navigation Risk Assessment



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# MetOcean for Çanakkale Bridge

## Caissons (sponsored by Daelim, Limak, SK and Yapı Merkezi)



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- **Preliminary Hydrodynamic Studies** (design conditions)
- **Measurement** (wind, wave, current, tide, water density)
- **Analysis** (vertical & horizontal profiles, spatial, temporal and reliability analysis)
- **Computer Simulations** (3D current, water density, water level)



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Measured & Modelled  
Surface Currents

