Module 3

Lecture 8

SHM layout design of offshore structures

offshore platform - lab scale

- SHM layout design

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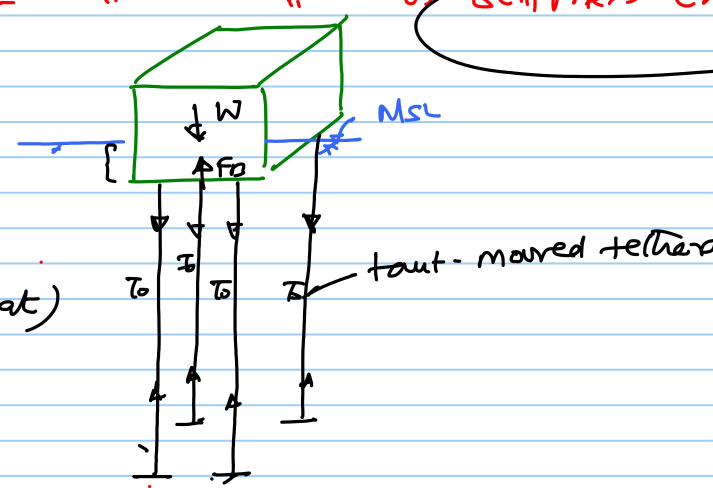
Offshore platforms : Structural Health Monitoring

one of the major challenges of SHM in offshore platform

- Non-stationary response
  - continuous change in mass (added mass)
  - " " in stiffness characteristics

Compliant structures
↳ flexibility



Basis :

W ↓ F_B ↑

$F_B >> W$ (afloat)

taut-moored tethers ↓ (T_0)

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$(T_{0}\downarrow + W\downarrow) = F_B\uparrow$

tensile force - axial tension - tether slackness
that changes the stiffness of the platform

- change is [K] || non-stationary
- change in [M]

- undergo major structural modifications

challenges safety of the platform ?

due to i) encountered environmental loads (wave, wind, current etc)

ii) [M] [K]

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Requirement - Response of the platform must be within the permissible limits

- all operations like drilling, production, storage, transportation etc can be carried out safely

- i) production activity
- ii) safety
- iii) serviceability

major factors, should be monitored

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Visual Inspection : Damage identification methods - successful through VI.

VI is not possible in offshore structures
- inaccessible (under water)
- hostile environment
- characteristics of the platform is changing continuously

An automated monitoring system
- monitor on a continuous basis
  - notify only when the characteristics are changed significantly.

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(i) Identify (any) Noticeable change

(ii) monitoring should be continuous

(iii) automated monitoring

(iv) Monitoring system to be simple, self-diagnosed and auto-tuned to the platform

- Inaccessible
- hostile Environment (VI x)
- undergoes changes continuously

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What parameters are important?

- automated, real-time interpretation

  (no packet loss in communication
  no data over-flow
  no malfunctioning sensors
  easy adaptability to WSN)

- different features
  - Threshold crossing
  - model parameter identification etc.
  - structural degradation (corrosion)

Global vibration-based damage detection

- applied to offshore structures – massive in size

If damage is due to some catastrophic effect,

- damage cannot be detected because of Marine growth
- poor visibility of the platform (members)

Need is to identify damage and by detecting change in significant characteristics

- Assessment

Benchmark case

That - change in properties - need to be compared with undamaged platform -

then a detailed numerical models of the platform its response behavior under environmental loads should be available

- Because to compare the damaged case with the above (undamaged case) to detect the changes → damage

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A thorough numerical models is essential

- frequency-domain approach is convenient to do this

(Kaiarain et al, 2013)

one of the major challenges is SHM design of offshore platforms :

(i) location of sensors ..

sensors placed close to the damage site (members) are influenced more than those placed away from the site

density of distribution of sensors!

{
- detects the damage, who fail
- makes localization of damage easy
}

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few more issues wrt vibration-based damage detection (Rice & Spencer, 2009)

(1) Noise measurements and Signal to noise ratio

(2) Discrepancy b/w scaled-down model and proto-type

(3) Non-linearity in the structural response

(4) Dense distribution of sensors

(5) Influence of environmental factors in real-time, which cannot be considered in the lab scale

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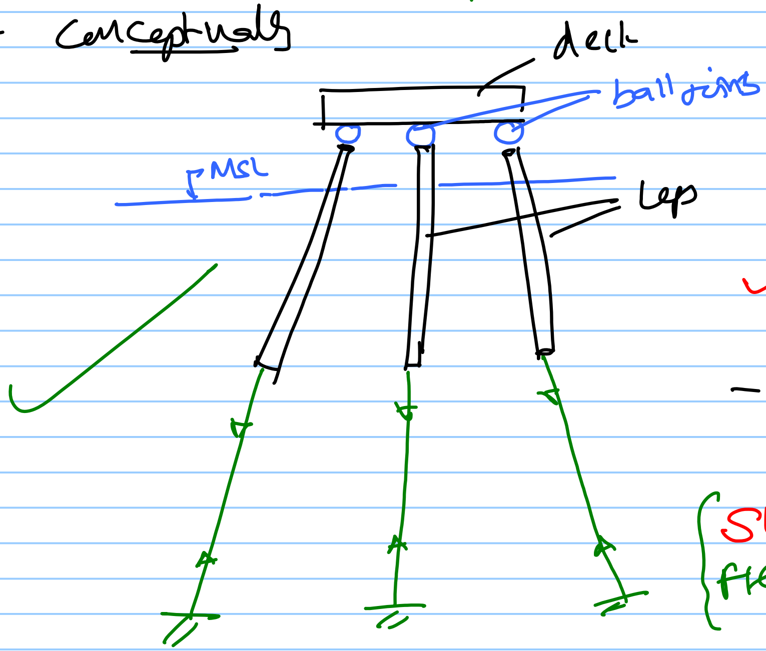
Application : New generation platform

Buoyant Leg, Storage & Re-gasification platform (BLSRP)

Novel – 2 years back – storage, regasification

- Conceptually



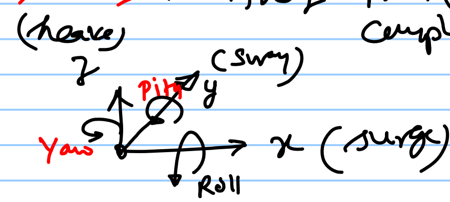
Ball Joints

- do not transfer rotation from legs to the deck & vice-versa

Yaw, pitch & roll ×

surge, sway, heave – they transfer translation completely

- dof



Stiff – vertical plane
Flexible – horizontal plane

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BLSRP - many complexities
- load
- geometry
- design

Wireless sensors - to measure/monitor the response of **BLSRP**

- postulated failure (initiate a failure)
and then detect the damage &
check the safety.

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(Chandrasekaran & Thakammai, 2016)
Chandrasekaran et al. 2015)

- WSN - (Yu & Ou, 2008)

- WSN - vibration-based monitoring

- performance of the platform
  - by measuring strain.
    displacement
    force
    accelerations

displacement is a major factor in design

focus: - level of damage
- location of damage | related to displacement and drift ||

when the platform undergoes dynamic behavior, damage reveals from the members - duration & bandwidth of acceleration data

- acceleration signal measured from a damaged model (postulated failure)
is compared with undamaged model
— significance of damage
extent of dam ||

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Lab scale

extreme-wave loading – under which damage can occur

- modeled Modified endurance wave analysis approach

- Effect of peak frequencies of PSD functions are considered

  - reduces the time history record

(Dastan et al. 2014,

Li et al, 2008,

Park et al. 2011)

- Design of STM – should be capable of recording/monitoring

  <u>relative motion</u> b/w the waves & the platform

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<u>Summary</u>

- Design of Stm layout
  - offshore structures
- offshore structures
  - BLSRP - geometric features / characteristics need to be monitored