Grillage modeling approach applied to simple-span slab-girder skewed bridges for dynamic analysis

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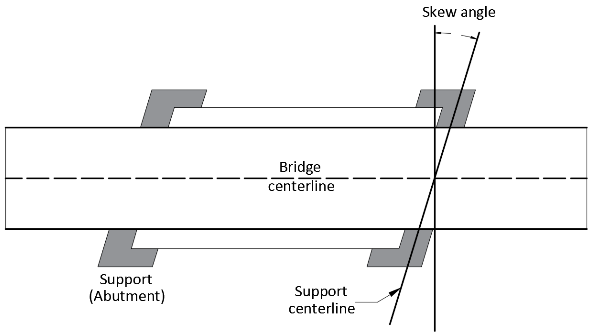
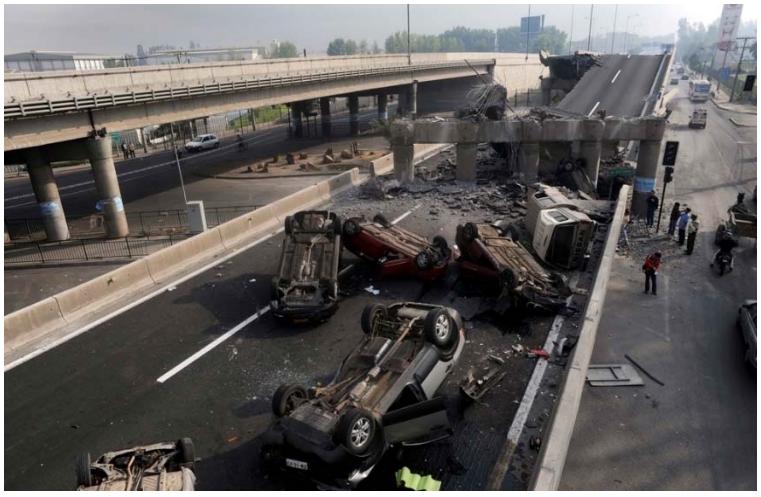
CONSTRUCT

Motivation and Objectives

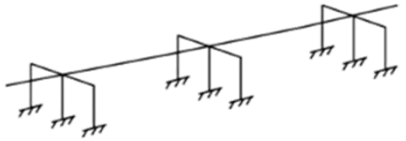


Seismic vulnerability of skewed highway bridges remains an important problem

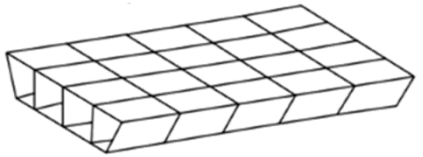


- Modeling assumptions had a direct effect on the results of previous studies.

Modeling Techniques

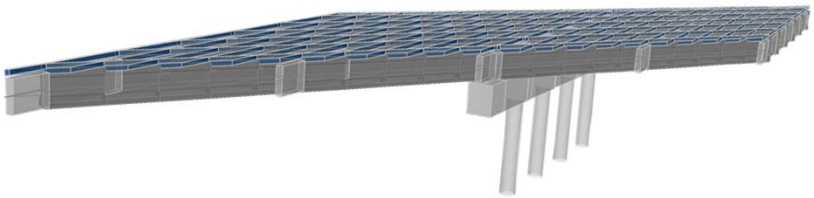


– BS models – no always capable of capturing certain predominant vibration (twisting and coupled flexural-torsional) modes



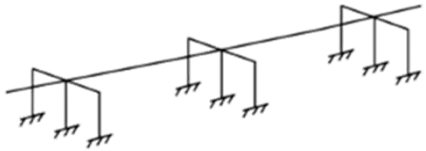
– 3D FE models – usually involves high computational time and effort

Motivation and Objectives



Improved BS models

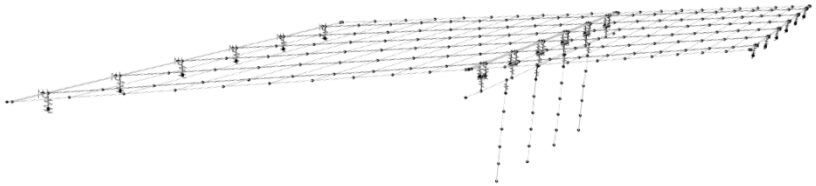
[Meng & Lui (2002), Abdel-Mohti & Pekcan (2013)]



The more number of lines of frames, the more accurate results

Grillage modeling approach

The **superstructure** is modeled with an **equivalent grillage** representing primary components of the bridge



Objective

- Evaluate the applicability of a simplified modeling technique to simple-span slab-girder skewed bridges for dynamic analysis, based on grillage modeling strategies.

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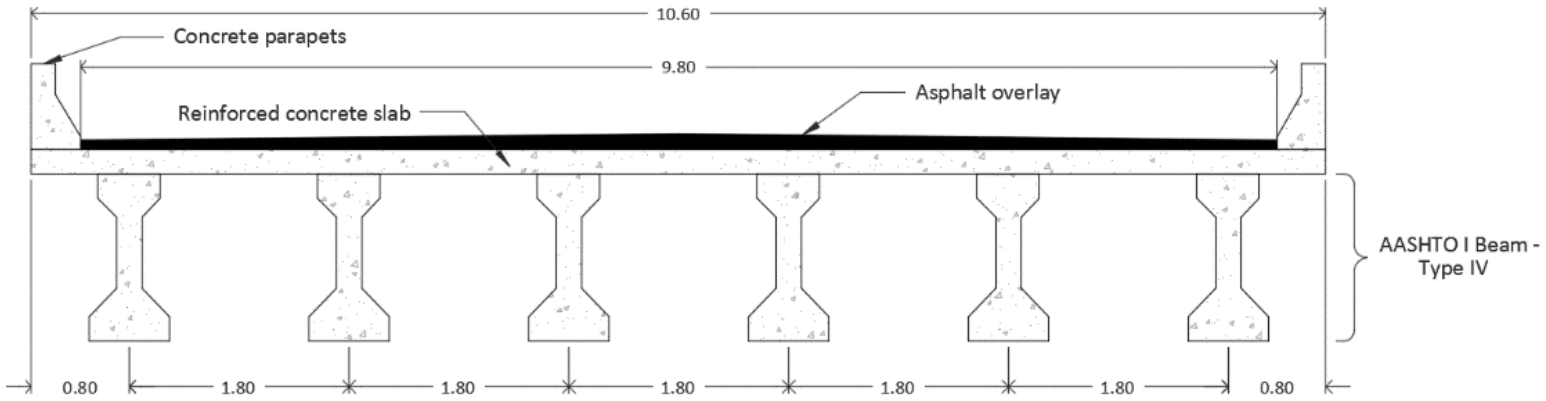
Description of the Study



- Bridge Models
  - Skew angle 0° to 60°
  - Span length L = 20 m
  - Superstructure width W = 10.60 m
  - Support conditions
    - Pinned bearings
    - Elastomeric bearings
  - Superstructure
    - Six Type-IV AASTHO PC girders
    - 0.20 m thick RC slab
    - RC end diaphragms
    - RC intermediate diaphragm aligned along the skew angle

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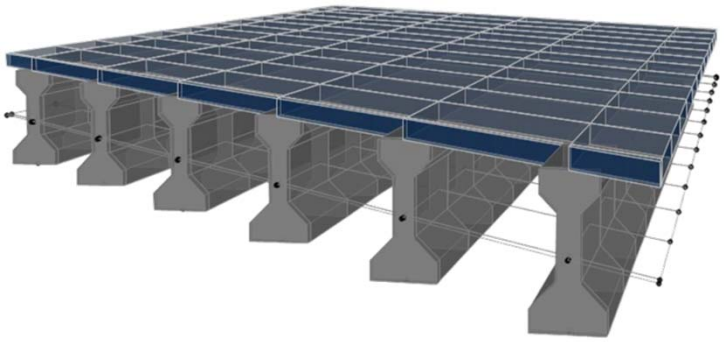
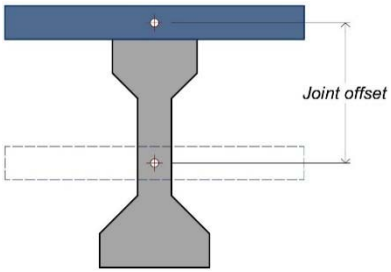
Finite Element Models

- 3-D FE model represents the superstructure components using shell and beam elements.

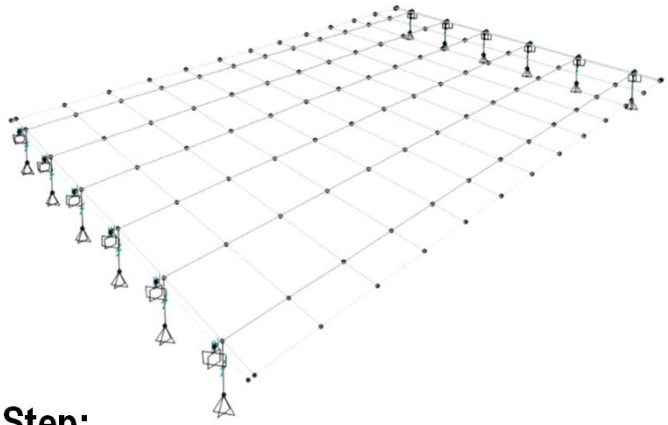


  - Connection between slab and girders achieved by assigning joint offsets



Grillage Models

- Grillage modeling approach steps:
  - (i) Simulate the bridge structure into equivalent grillage mesh, and
  - (ii) Assign appropriate elastic properties to each member of the grillage.



1st **Step:**

A suitable grillage mesh for skewed bridges much depends upon the **skew angle**, the **span length**, and the **width of the deck**.

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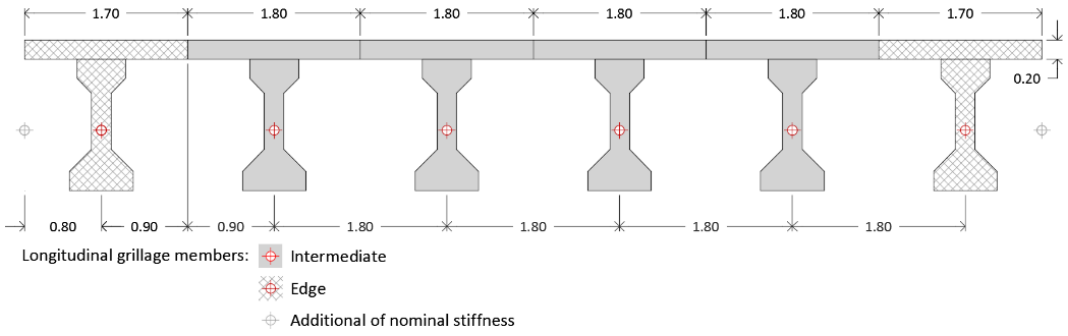
Grillage Models

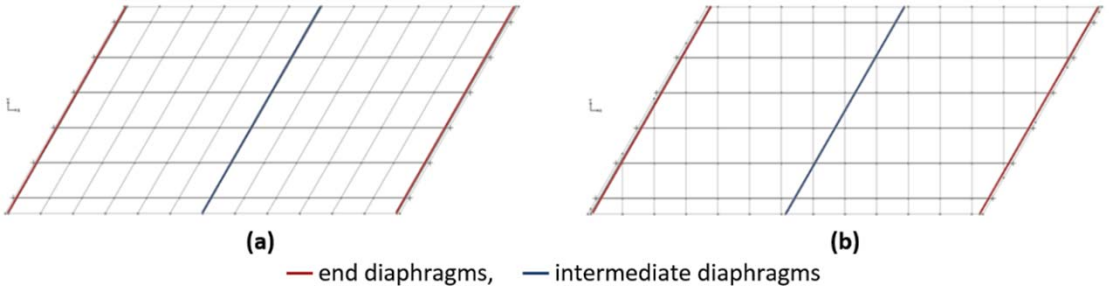
2nd Step: Assign appropriate elastic properties to each member of the grillage

Similitude of moments E_c , I

Similitude of twisting and torques G_c , T

- Longitudinal Grillage Members (LGMs)





- Transverse Grillage Members (TGMs)

(a) TGMs in the direction of the skew angle, and

(b) TGMs perpendicular to the LGMs

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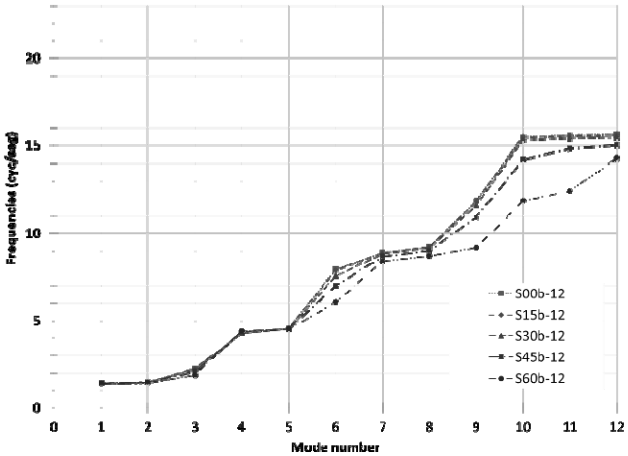
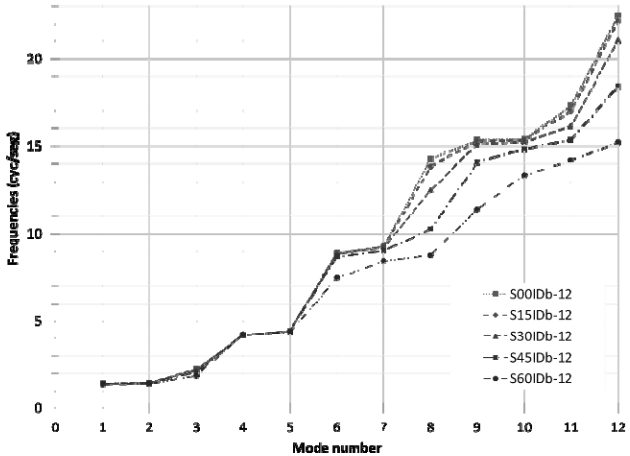
Natural Vibration Frequencies – FE Models

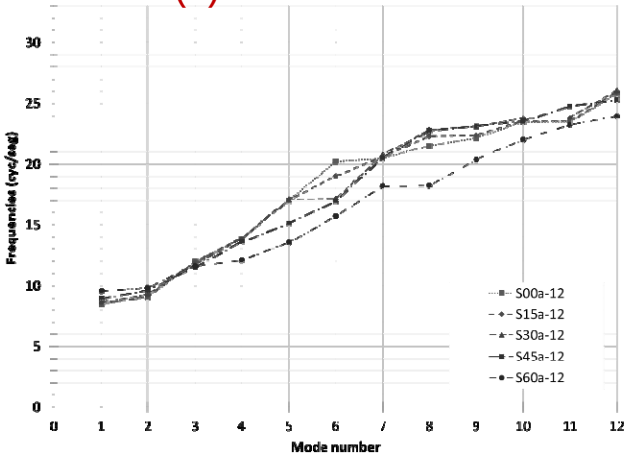


(a) without ID

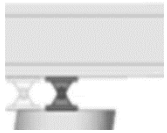
Elastomeric bearings



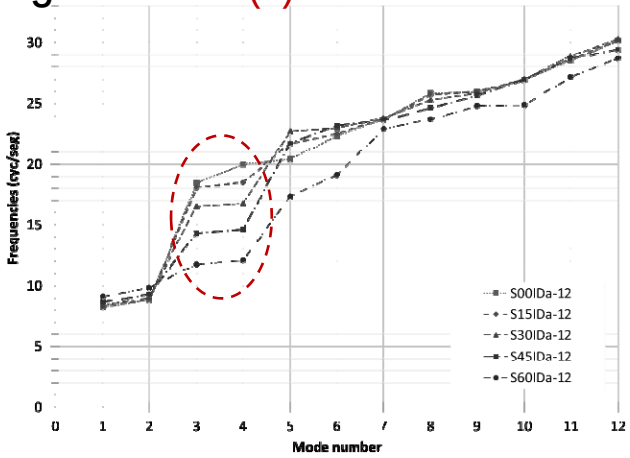
(b) with ID



(a) without ID



Pinned bearings



(b) with ID

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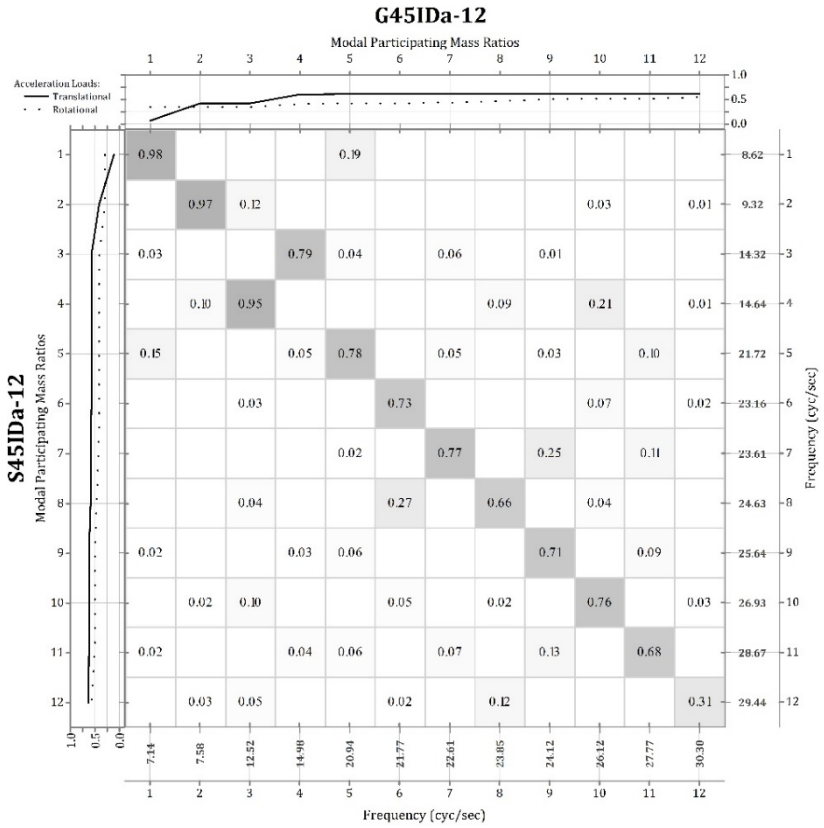
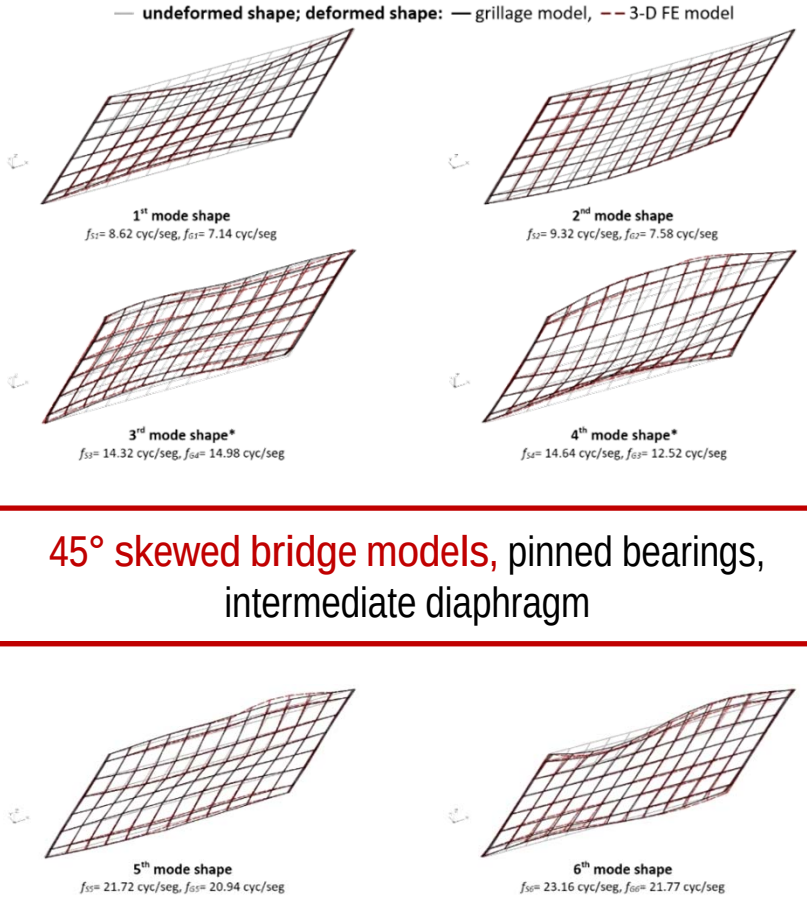
Comparison of Bridge Modeling Techniques

- Grillage models & 3-D FE models
  - Natural vibration frequencies, mode shapes, and modal participating mass ratios





45° skewed bridge models, pinned bearings, intermediate diaphragm

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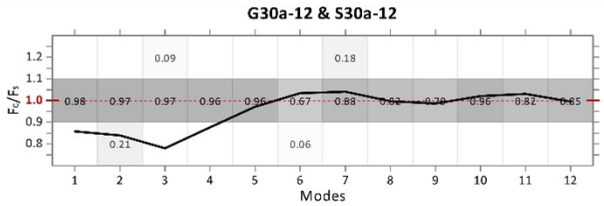
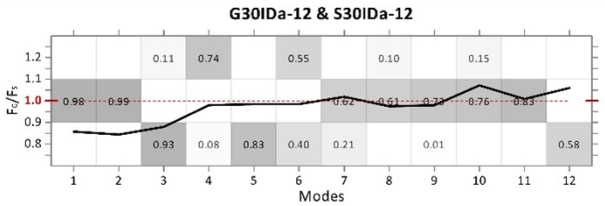
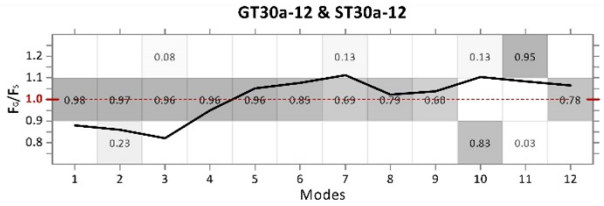
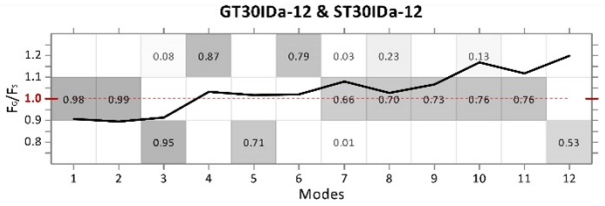
Comparison of Bridge Modeling Techniques







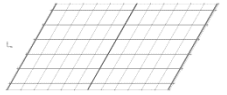


without ID

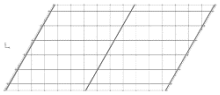
(c) 30°

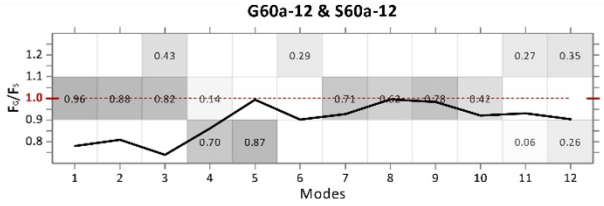
with ID

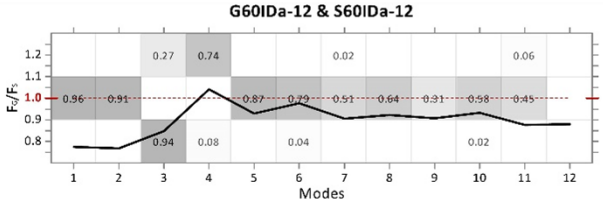
TGMs in the direction of the skew angle



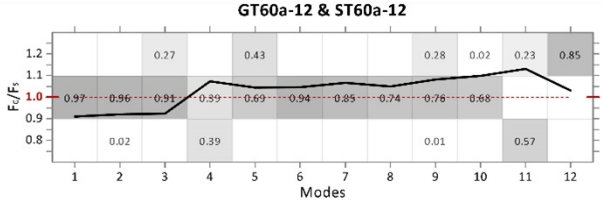
TGMs perpendicular to the LGMs

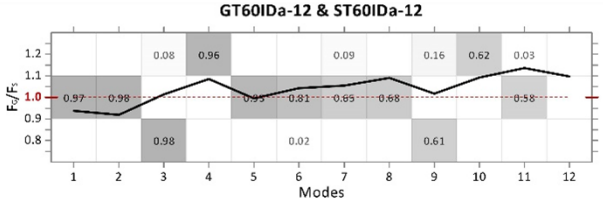






TGMs in the direction of the skew angle





TGMs perpendicular to the LGMs

(e) 60°

Main diagonal of MAC matrixes, bridge models supported on **pinned bearings**

Conclusions

The following conclusions could be drawn based on the results:

- The first natural vibration frequencies for the bridge models supported on **elastomeric bearings** are not greatly affected by the **skew angle**,
- According to the comparative analysis, **grillage models** are able to accurately capture **higher vibration modes**,
- By orienting the **TGMs perpendicular to the LGMs** does not greatly improve the ability of the grillage models to capture the vibration modes.

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- The reduction of DOFs in the bridge models make that the implementation of grillage modeling approach suitable for computationally intensive studies, as those with involve a large number of nTHAs.