

Innovations in Slab Systems

Voided Slab Technology

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INTRODUCTION مقدمة

- Conceptually a good design only if $(LL/DL < 1)$
- DL increases with span in RC structures
- Solutions:
 - Avoid tension in selection of structural systems (dome, arch, ...)
 - Prestressed concrete
 - Voided slab
 -

SLAB PERFORMANCE REQUIREMENTS

Structure

- | | |
|-------------------|---------|
| 1. Strength | القوة |
| 2. Serviceability | المنفعة |
| 3. Stability | الثبات |

Other requirements. المتطلبات تزداد باستمرار
(durability, thermal protection, sound absorption, fire resistance, economical requirements....)

Slab Performance Requirements

متطلبات أداء البلاطات



- Must support loads: **strength: essential.**

لدعم الأحمال ← قوة

- Must have adequate stiffness:
serviceability: essential

صلابة مناسبة ← منفعة

- Withstand severe events
(earthquakes...): **stability: optional**

دعم أحمال شديدة (الزلازل ...) ← ثبات

Slab Performance Requirements

متطلبات أداء البلاطات

Axial stiffness hundred times flexural stiffness



CHARACTERISTICS OF INNOVATIVE DESIGN

- Innovative design: sustainability
التصميم الإبداعي هو تحقيق الحاجة من خلال المصادر المتوفرة (الديمومة)
- Voided slab removes/replaces concrete with lighter material.
- However, cavities decrease the slab resistance to shear.
- Ribbed slab: decrease dwell action, aggregate interlock

Characteristics of innovative design

- Very simple
- Cost effective
- Environment effective
- Sustainability
- Earthquake design?

History: Pal Kal System



• Before قبل الصب

- Concrete thickness in the lower flange
- Lower flange rebar location, diameter and dimensions

• During أثناء الصب

- Concrete web width and their continuity
- Concrete web height
- Presence of vertical rebar in the webs, its location, diameter and height above the lower flange
- Penetration depth of the Pal-Kal sheets to the lower flange
- Geometric shape of the Pal-Kal sheets

History of Voided Slabs in Palestine

- Example in Nablus
- Lecture from inventor of Pal-Kal

Debates

- Shear
- Earthquake resistance





- The **Versailles wedding hall** in [Jerusalem](#)
- 23 people dead, 380 were injured



- At start: the cause is Pal Kal
- Later investigations:
 - An additional story was built
 - Internal partitions were removed, few inches deflection were noticed, considered as aesthetic problem solved by injection

Theoretical Comparisons

- Analysis: based on assumptions (can be modified, no problem)
- Design:
 - Flexure: minor, major players are f_y , A_s , d
 - Deflection: minor
 - Shear: major loss in aggregate interlock

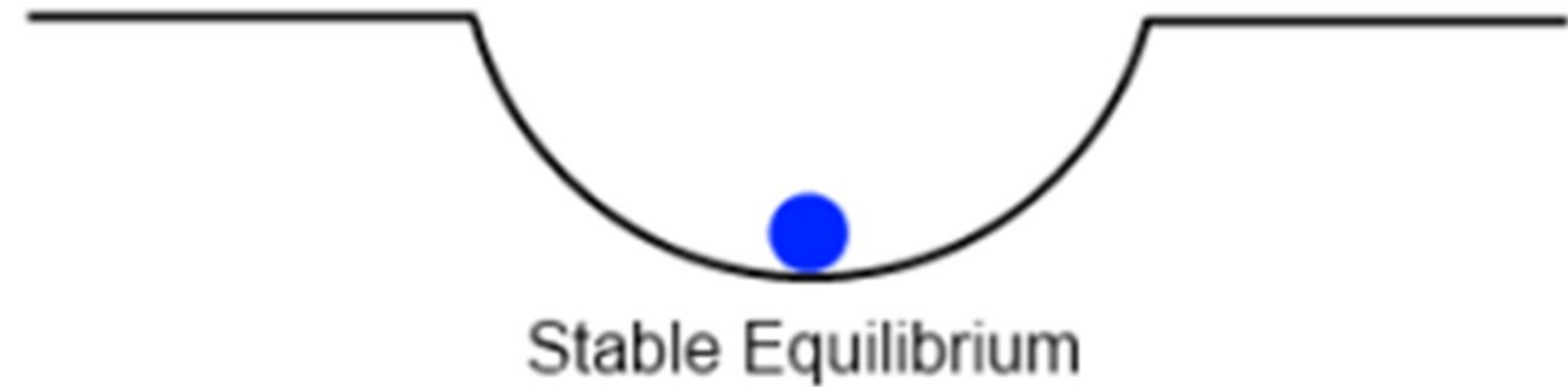
Theoretical Comparisons

- Assumptions
- Theories
- Facts



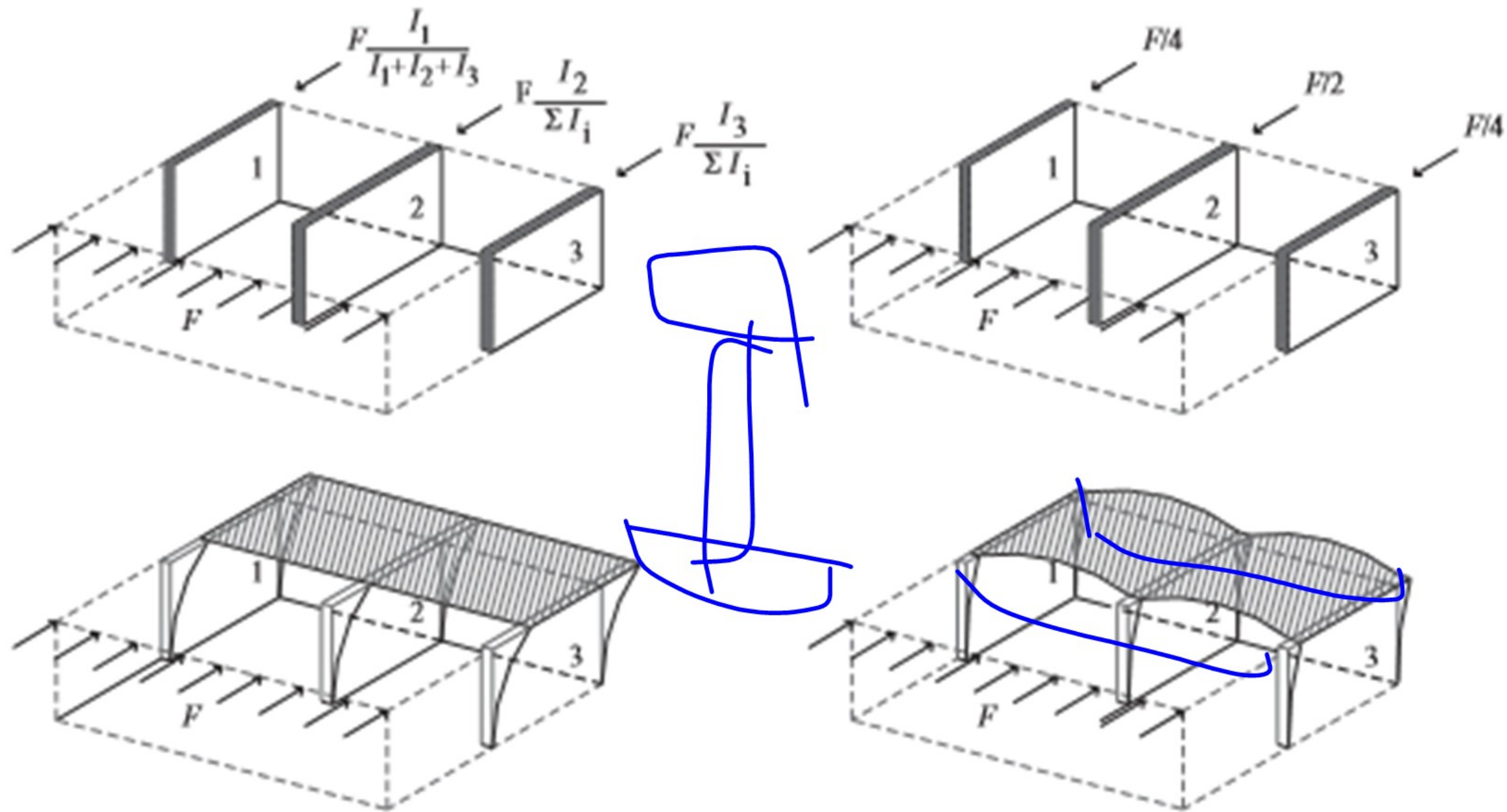
Theoretical Comparisons

Earthquakes



Theoretical Comparisons

Earthquake Loads



Theoretical Comparisons

مقارنات نظرية

	Waffle with beams	Ribbed with beams	Solid with beams	Solid without beams	Voided slab with beams
Vertical M	LV	LV	LV	LV	LV
Vertical V	HV	HV	LV	V	HV
Vertical δ	HV	HV	LV	V	V
Lateral M	LV	LV	LV	LV	LV
Lateral V	HV	HV	LV	V	HV
Lateral Δ	HV	HV	LV	V	V
weight	V	V	HV	HV	LV
assumptions	HV	HV	LV	LV	V

v=vulnerable, L=least, H=high

Types of Voided Slabs

- Forms can take any shape to fit the particular

need: spherical, cubic, ...

- Material of form: disposal for environment

protection

Examples

أمثلة

-Imitating new entry:

تصميم مظلة الحاج طاهر المصري/الدوار

-Enhancing new entry:

فيلا في نابلس























Conclusions

- First duty: safety
- Be careful in shear
- Use voided for long spans
- better than ribbed slabs for earthquake resistance
- Use false ceiling

تذكير Reminder

قَدْ مَكَرَ الَّذِينَ مِنْ قَبْلِهِمْ فَآتَى اللَّهُ بُيُوتَهُمْ مِنَ الْقَوَاعِدِ فَخَرَّ عَلَيْهِمُ السَّقْفُ
مِنْ فَوْقِهِمْ وَأَتَاهُمُ الْعَذَابُ مِنْ حَيْثُ لَا يَشْعُرُونَ (26) النحل

أَأَنْتُمْ أَشَدُّ خَلْقًا أَمْ السَّمَاءُ بَنَاهَا (27) رَفَعَ سَمَكَهَا فَسَوَّاهَا
 (28) النازعات

اللَّهُ الَّذِي رَفَعَ السَّمَاوَاتِ بِغَيْرِ عَمَدٍ تَرَوْنَهَا... (2) الرعد



شکرا احسن استماعکم

*Thank
You*



الأسئلة