FOUNDED 1999

Meeting Minutes

IABMAS Technical Committee on Bridge Load Testing

Online, Zoom https://usfq.zoom.us/j/87303749556

Monday October 25th, 9am – 11 am EDT (US Eastern) / 3 pm – 5pm CET (Central European)

Mission: *Bridge Load Testing is a field testing technique that can be used to obtain more information about the performance of bridges. In particular, diagnostic load tests can be used to quantify elements of structural performance such as transverse distribution, unintended composite action, repair effectiveness, etc. and the information of a diagnostic load test can serve to develop field-validated models of existing bridges that can be used to develop a more accurate assessment of the bridge's performance. Proof load testing can be used to demonstrate directly that a bridge can carry a load that is representative of the code-prescribed live load, provided that the bridge does not show signs of distress. Other types of load testing include testing for dynamic properties, and parameter-specific tests. Load test data as well as the analytical assessment of the data can be used to make more informed decisions and manage the life-cycle performance and maintenance of bridges.*

Aspects of bridge load testing that are of particular interest to bridge owners are having an overview of the typical uses for bridge load tests, the decision on when to load test or not, which information to obtain from the load test, and how this information can be used to reduce the uncertainties regarding the tested bridge. This committee is eager to learn about and disseminate the potential for applying new technologies for bridge load testing through learning from technologies used in other industries.

Associated with bridge load testing, the following topics are also of importance to this committee: instrumentation used during load testing and the interpretation of the obtained measurements during the load test, determination of required load, method of load application, methods of updating assessments using collected field data, the link between load testing and structural health monitoring, the uncertainties (probabilistic aspects as well as risks during test execution) associated with load testing, the interpretation of load test results, laboratory testing of bridge components to improve assessment methods in the field, and optimization of related costs keeping adequate reliability to spread their use worldwide.

The IABMAS Bridge Load Testing Committee aims to be an international committee of participants from academia, industry, and bridge owners, which provides a forum for the exchange of ideas on bridge load testing. Best practices as well as the insights from the development of national codes and guidelines will *be exchanged among participants from countries that use load testing for the assessment of their existing bridges, those who are exploring the possibilities of this method, and those who are in the process of standardizing the procedures or developing guidelines.*

Goals:

- *Organize dedicated sessions to the topic of load testing at IABMAS conferences.*
- *Develop national IABMAS group events on the topic of load testing.*
- *Exchange information on the use of load testing in different countries.*
- *Exchange lessons learned and best practices.*
- *Inform about case studies of bridge load testing.*
- *Communicate load testing guides or standards that have been developed.*
- *Provide a forum for new ideas and applications of technology.*
- *Identify potential research topics.*
- *Establish international collaborations.*
- *Liaise with relevant committees internationally outside of IABMAS and liaise with the national IABMAS groups.*

Committee Members

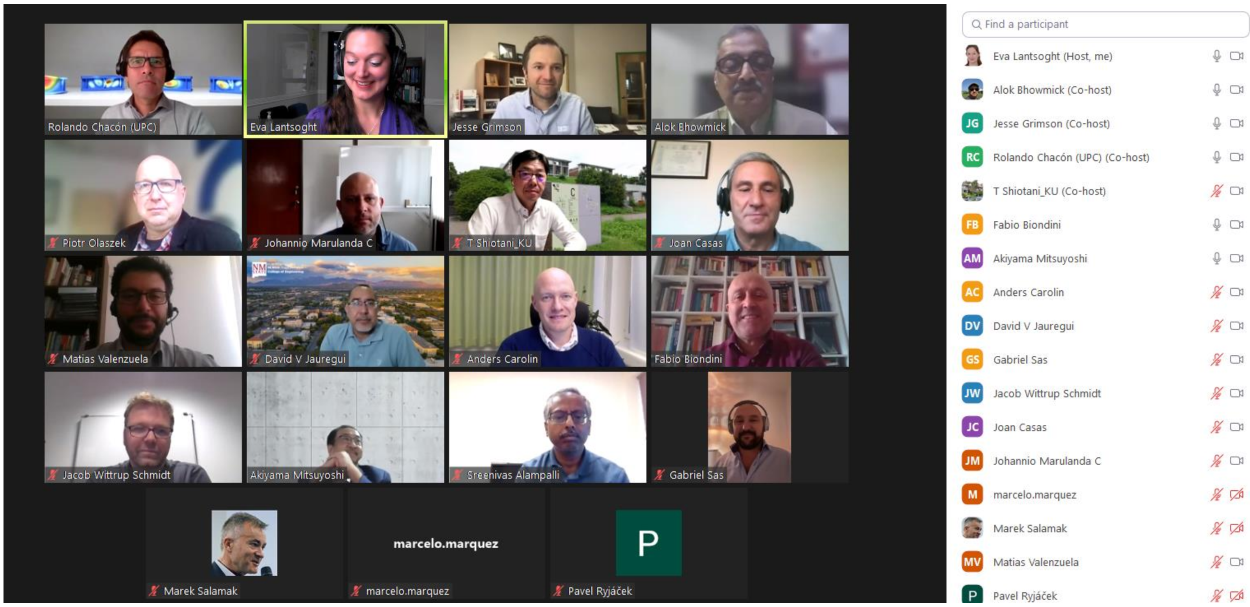
Eva Lantsoght
Jesse Grimson
Mitsuyoshi Akiyama
Sreenivas Alampalli
Fabio Biondini
Alok Bhowmick
Jonathan Bonifaz
Anders Carolin
Joan Ramon Casas
Rolando Chacon
Dave Cousins
Dan Frangopol
Boulent Imam
David Jauregui
Ho-Kyung Kim
David Kosnik
Marcelo Marquez
Johannio Marulanda
Piotr Olaszek
Pavel Ryjacek
Marek Salamak
Gabriel Sas
Gregor Schacht
Jacob Schmidt
Tomoki Shiotani
Matias Valenzuela
Esteban Villalobos Vega
David Yang

Regrets: Boulent Imam, Dave Cousins, Esteban Villalobos Vega, David Kosnik, Gregor Schacht, David Yang

1. Administrative

1.1. Welcome and introduction

All participants introduced themselves and their affiliation.



1.2. Review and approval of agenda

The agenda was approved without comments.

2. Strategic Planning and Discussion

2.1. Membership

Lantsoght mentioned that the committee would welcome participation from additional bridge owners.

2.2. Website

Lantsoght mentioned that the committee information is now added to the IABMAS website and thanked Akiyama. Frangopol mentioned that we could add a call for collaborations on our website, as well as announce this committee to more people. Grimson mentioned TRB AKB40 as a potential liaison and place to announce this committee. Carolin will share the information about the committee with other inframanagers. Bhowmick will reach out to the Indian roads congress IRC, and mentioned that committee B8 was formed about a week ago. Valenzuela mentioned the International Bridge Conference of Chile which will take place later this week (Oct 27th – 29th).

3. New Business [90 min]

3.1. Technical presentations

1. Bridge load testing practice in India – Alok Bhowmick
2. Assessment of bridge deck performance with overall elastic wave velocity -Case study before/ after repair works- Tomoki Shiotani
3. "Digitally twinned load tests in railway bridges" – Rolando Chacon

Three technical presentations were presented. The slides of these presentations are added to the minutes of this meeting.

3.2. Opportunities for collaboration

Grimson listed the Committees mentioned earlier on the call: TRB AKB40, IRC code, groups of owners in Europe.

Bhowmick informed about the possibility for this committee to compile a state of the practice of load testing internationally. Grimson mentioned that this topic was mentioned in the previous meeting that there is interest in compiling information on load testing on various parts in the world. Lantsoght suggested that we could develop a template for filling out. Alampalli mentioned that we could have a special session (workshop) at the IABMAS symposium. Carolin mentioned the opportunity to collaborate with members in large tests that are planned. Grimson mentioned the possibility to share upcoming tests within the committee. Sas mentioned two tests that are upcoming in Sweden where the collaboration with members from this committee can be welcome.

Jauregui mentioned the AASHTO Committee on Bridges and Structures, and this committee can have contacts internationally on the owner side. Their next meeting will be in June 2022 in Pittsburgh. For reference, the website is https://bridges.transportation.org/ .

Lantsoght will reach out to ACI 342 and fib TG 3.2 for potential liaison.

3.3. Upcoming conferences and events

- 76th RILEM week Kyoto, 3-9 Sep 2022 https://rilemweek2022.jp
- IABMAS Barcelona, July 11-15 2022 https://congress.cimne.com/iabmas2022/frontal/default.asp
- TRB Annual meeting January 2022 https://www.trb.org/AnnualMeeting/AnnualMeeting.aspx
- IABMAS US meeting, potentially January 2022
- European Working Group on Acoustic Emissions, EWGAE2022, September 13th – 16th, Ljubljana, Slovenia, https://ewgae2022.si and http://www.ewgae.eu/page.html
- World Conference on nondestructive testing, May 30 – June 3, Incheon, South Korea, https://www.20thwcndt.com

4. Adjournment [10 min]

Next meeting – Tentatively: Spring 2022

BRIDGE LOAD TESTING PRACTICE IN INDIA

Alok Bhowmick
Fellow, National Academy of Engineering
International Professional Engineer(India)
Managing Director, B&S Engineering Consultants Pvt. Ltd.

OVERVIEW OF THE PRESENTATION

1. Introduction
2. Load Testing – Current IRC Standards
3. Appraisal of the IRC Standard on Load Testing
4. Summary & Conclusions

OVERVIEW OF THE PRESENTATION

1. Introduction
2. Load Testing – Current IRC Standards
3. Appraisal of the IRC Standard on Load Testing
4. Summary & Conclusions

INTRODUCTION

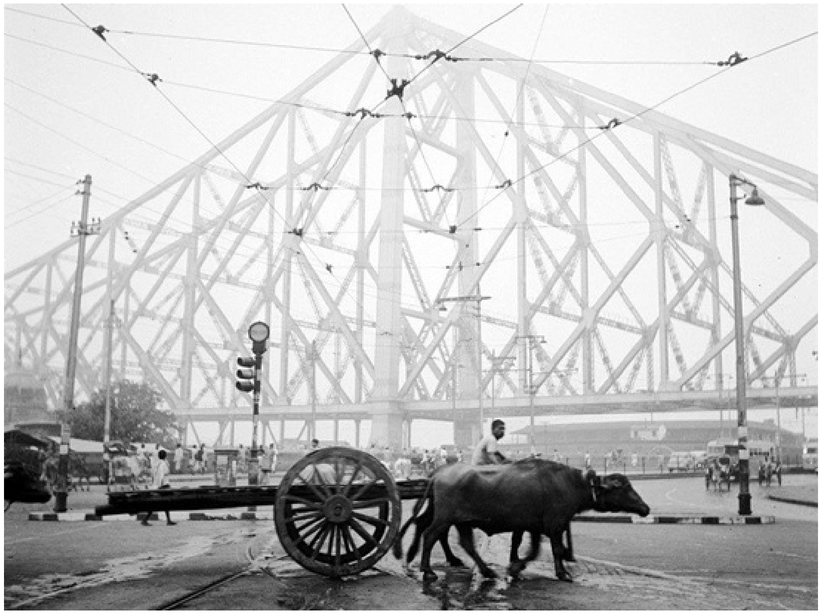
1. **India has an extensive road network that constitutes a substantial investment.**

S. No.	TYPE OF ROAD	LENGTH (Km)
1	National Highways	1,32,500 (1.8%)
2	State Highways	1,76,166 (3.14%)
3	District Roads	561940 (10.3%)
4	Rural Roads	3935337 (70.23%)
5	Urban Roads	509730 (9.10%)
6	Project Roads	319109 (5,70%)
7	Total	58,98,000 km

2. **Bridges form a significant component of the value of the transport network. There are about 120 lacs bridges that exists throughout the country. 5% of these are estimated to be in distress.**

INTRODUCTION

3. **The road network is increasingly being called upon to carry heavier loads due to pressure to improve transport productivity by increasing legal loads.**

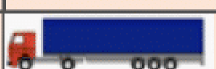
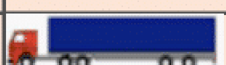


1960

2020

IABMAS

INTRODUCTION

REVISED GVW OF TRANSPORT VEHICLES AFTER REVISED SAFE AXLE LOAD AND 5% TOLERANCE BY MoRTH (16-07-2018)														
SN	AXLES AND TYRES TYRES & VEHICLE'S COMMON NAME	VEHICLE WITH AXLES AND WHEELS DIAGRAM	NUMBER, POSITION AND TYRES OF AXLES								GVW (KGS)			
			FRONT				REAR			TOTAL AXLES	PRESENT	ENHANCED	With 5%. Tolerance
			1st	2nd	3rd		1st	2nd	3rd				
1	6tyre truck		2				4			2	16200	19000	19950
2	10 tyres multy axle truck		2				4	4		3	25000	28500	29925
3	12 tyre single chassis rigid truck		2	2			4	4		4	31000	36000	37800
4	12 tyre single chassis rigid truck		2				2	4	4	4	31000	36000	37800
5	14 tyre single chassis rigid truck		2	2			2	4	4	5	37000	43500	45675
6	14 tyre single chassis rigid truck		2	2			4	4	2	5	37000	43500	45675
7	14 tyres semi trailer		2	4			4	4		4	35200	40000	42000
8	18 tyres semi trailer		2	4			4	4	4	5	40200	46000	48300
9	18 tyres semi trailer		2	4	4			4	4	5	40200	49500	51975
10	22 tyres semi trailer		2	4	4		4	4	4	6	49000	55000	57750

Government raises load capacity for heavy vehicles by 20-25 per cent

ET Bureau • Last Updated: Jul 17, 2018, 07:33 AM IST

Synopsis
The gross vehicle weight of a two axle truck (two wheels in the front axle and four wheels in the rear) has been increased to 18.5 tonne from the existing 16.2 tonnes, increasing the load carrying capacity by just over 20%.

The statutory order was issued by the road transport and highways ministry late on Monday.

NEW DELHI: The Centre has increased the official maximum load carrying capacity of heavy vehicles, including trucks, by 20-25% besides scrapping the mandatory annual renewal of fitness certificates for freight carriers.

Stocks of truck makers have corrected in recent days on concerns that higher load capacity would hurt demand for

As per Motor Vehicle Act, the Legal Axle load limit notified in July, 2018 is 11.5 tonne, 21 tonne and 27 tonne for Single, Tandem and Tridem Axles respectively

INTRODUCTION

4. **Many of the existing bridges are designed for lesser loads than current legal loads / loads actually plying. In many of these bridges, load restrictions are being applied. The load restrictions do not accurately reflect the actual load capacity of the structure.**

IRC 6 – 1958

- Class A Loading
- Class B Loading
- Class AA Loading

IRC:6-2017

SECTION: II
LOADS AND LOAD COMBINATIONS
(SEVENTH REVISION)
(incorporating all amendments and errata published upto March, 2017)

IRC 6 – 2017

- Class A Loading
- Class B Loading
- Class AA Loading
- Class 70R Loading
- SV Loading
- Congestion Factor Loading

INTRODUCTION

5. Load testing has been one of the recognized methods to evaluate and rate bridge structures.

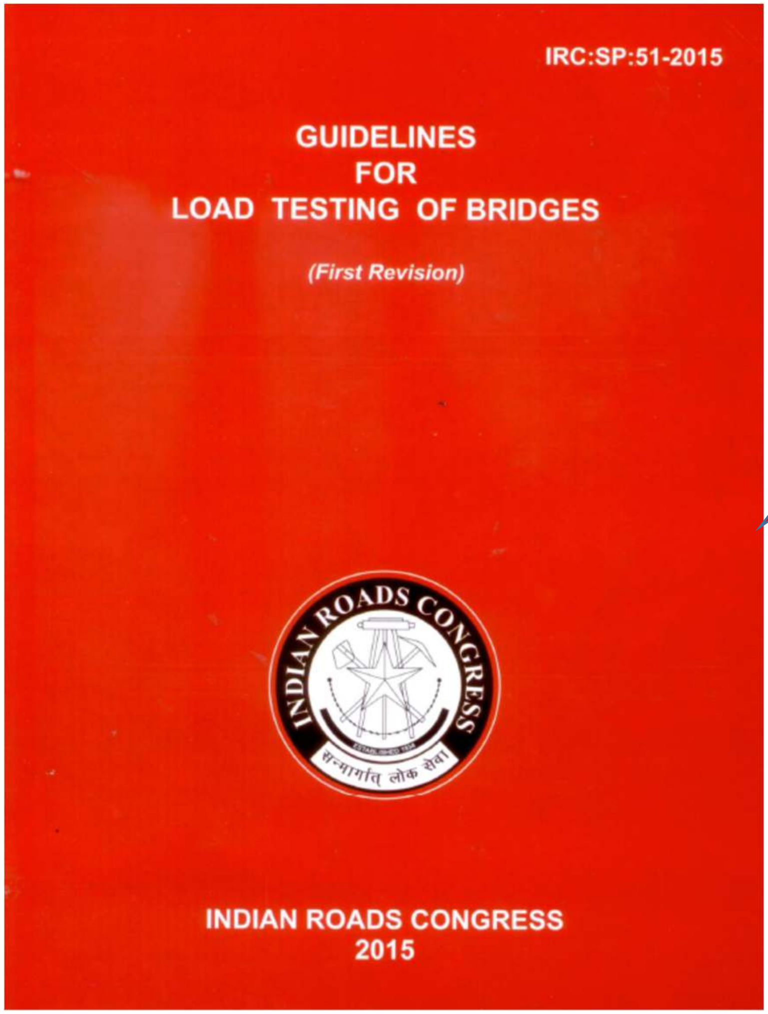
6. While advanced analytical methods are available to determine the ultimate capacity of existing structures, timely and accurate in-service data needed for model input and service life prediction is not always forthcoming.

7. Load testing provides a useful alternative for such cases where current calculation methods, for one reason or another, cannot provide satisfactory answers to performance questions on existing bridges.

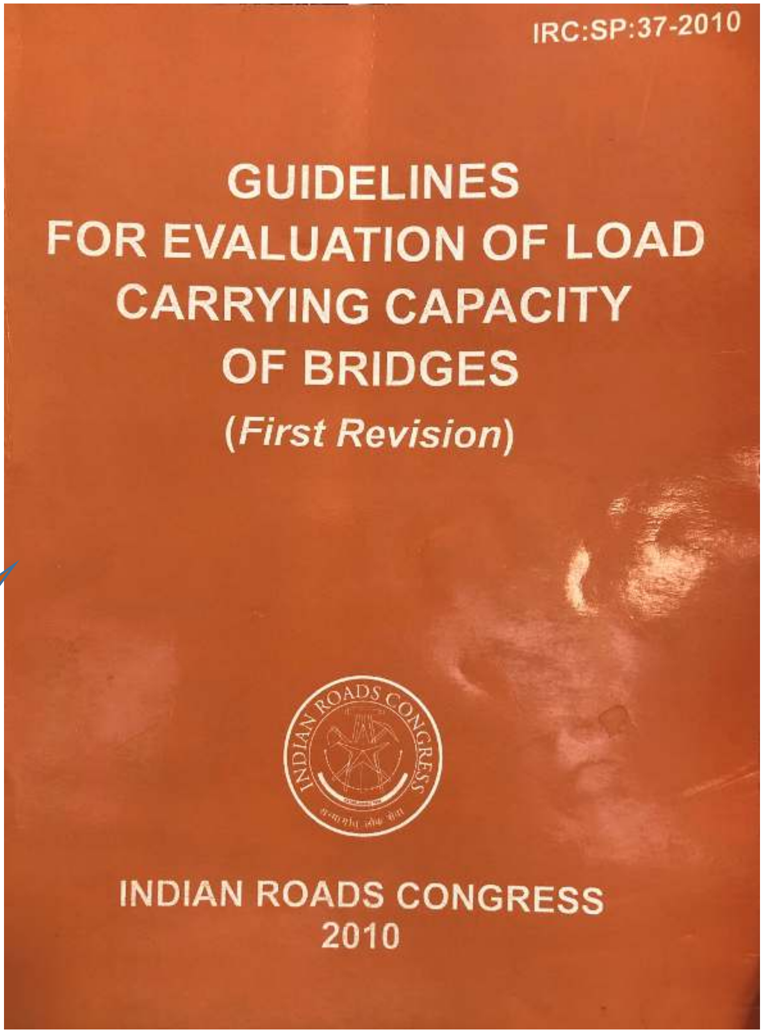
OVERVIEW OF THE PRESENTATION

1. Introduction
2. **Load Testing – Current IRC Standards**
3. Appraisal of the IRC Standard on Load Testing
4. Summary & Conclusions

LOAD TESTING – CURRENT IRC STANDARDS



APLICABLE FOR LOAD TESTING OF NEW BRIDGES & RETROFITTED BRIDGES



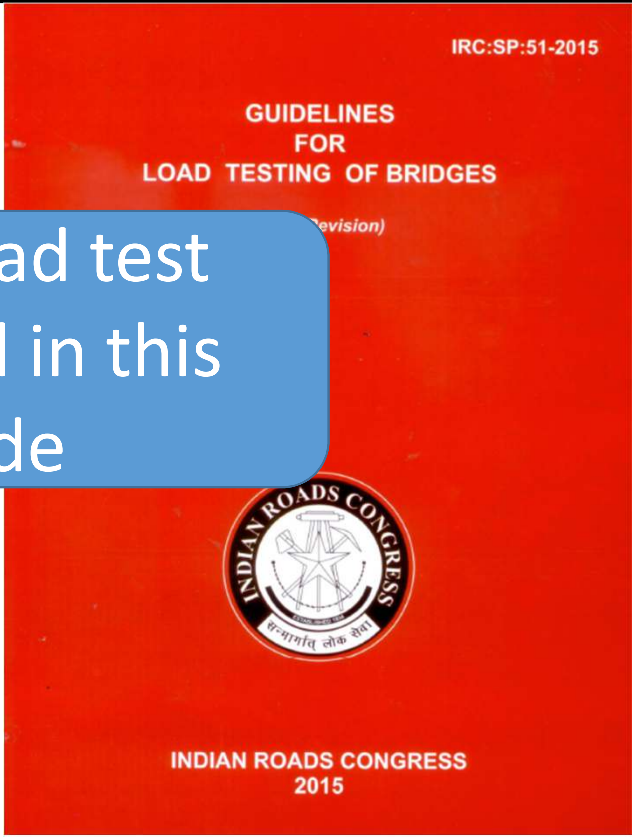
APLICABLE FOR LOAD TESTING OF EXISTING BRIDGES

LOAD TESTING – CURRENT IRC STANDARDS

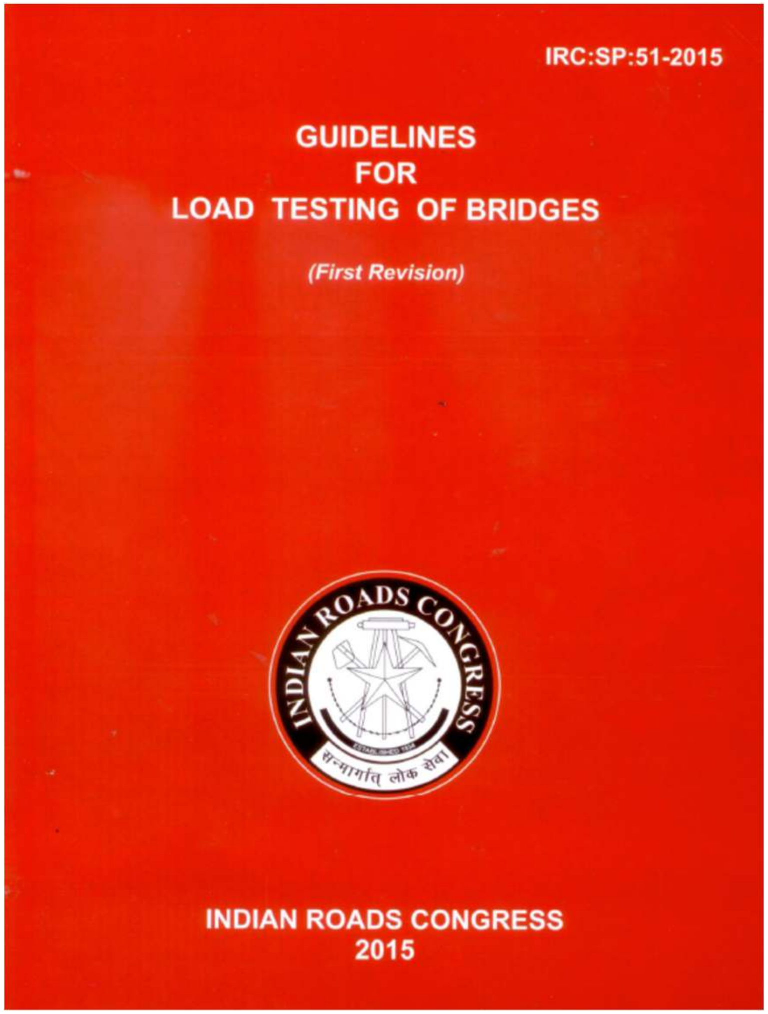
TYPES OF TESTS SPECIFIED (For Information) :

- Design assisted by Testing
- Proof Load Tests
- Behaviour Tests
- Diagnostic Load Tests
- Load Tests for Rating and Posting of Bridges
- Confirmatory Tests after Repair and Rehabilitation
- To establish stress range for fatigue tests
- Dynamic load tests

Only load test covered in this code



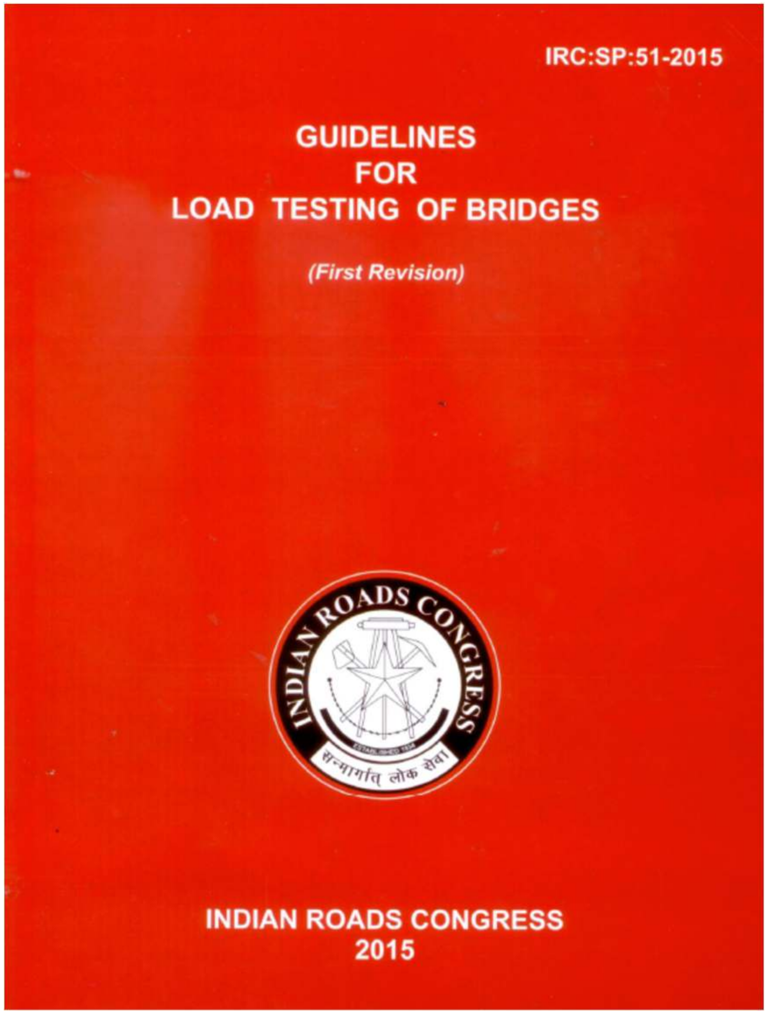
LOAD TESTING – CURRENT IRC STANDARDS



IRC:SP:51

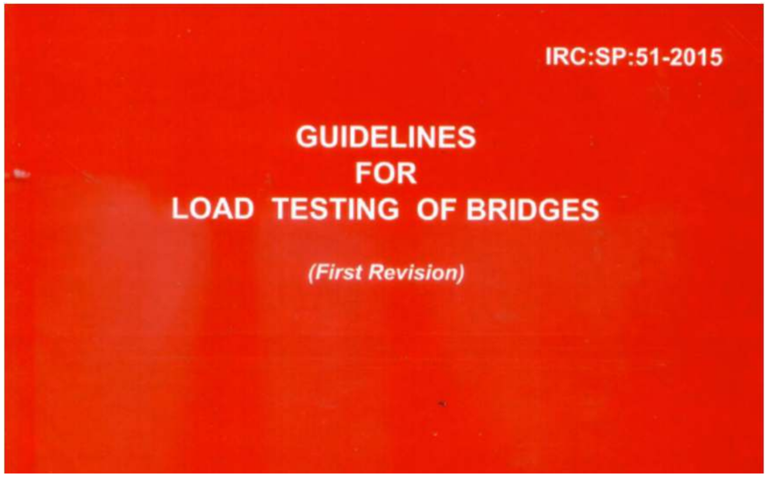
- Deals with Proof Load Test of Superstructure.
- Used for assessing the behaviour of a bridge by application of design IRC:6 live loads over a longer period of 24 hrs for confirmation of the elastic performance.
- Do not cover testing of Arches
- Testing for shear capacity not considered
- Testing for ULS not considered
- Acceptance Criteria :
  - Measured deflections shall be equal to or less than theoretical deflections.
  - % Recovery of Deflection @ 24 hours shall be not less than 75% (RCC & Composite) and 85% (PSC & Steel) Superstructures

LOAD TESTING – CURRENT IRC STANDARDS



IRC:SP:51 : OBJECTIVE OF LOAD TEST

NEW BRIDGE	EXISTING / RETROFITTED BRIDGE
1. Demonstrates that bridge fulfils code requirements	1. Sometimes load test is done before repair / rehab to study and observe behavior …such as stresses, deformations, vibrations….etc.
2. Confirms that bridge behaves as per design intent	2. Load tests are done at times after repair and rehabilitation to demonstrate the efficacy of the repair measures.
3. Verify the Design Parameters considered in Design (E, I)	

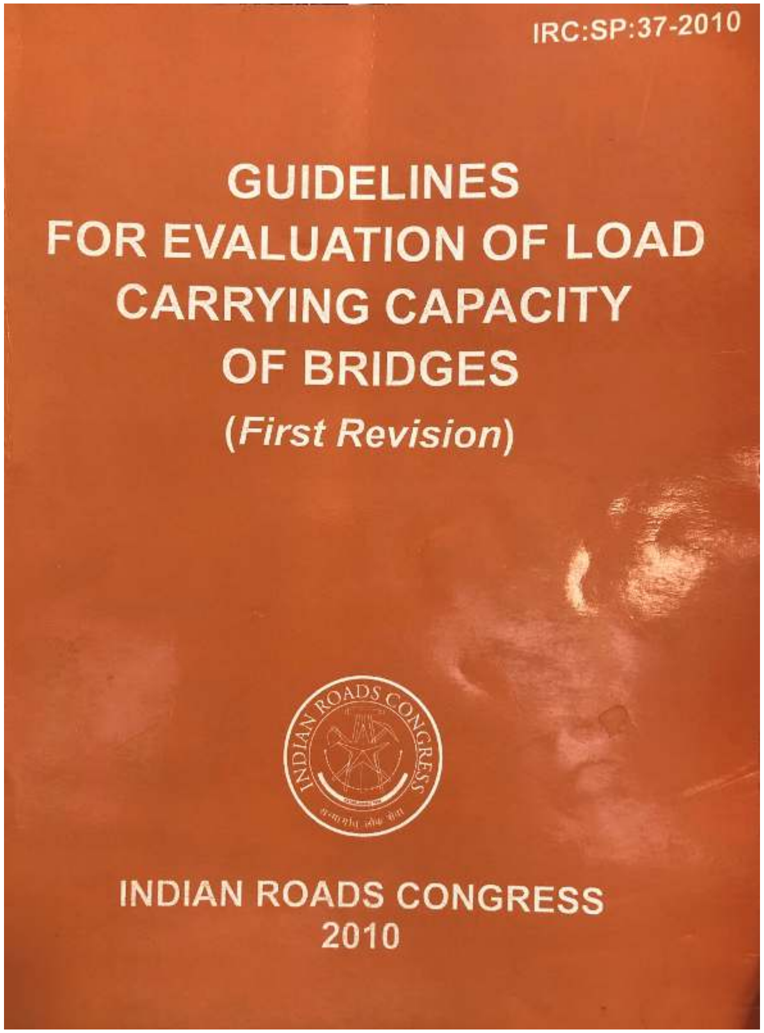


IRC:SP:51 : Brief about Loading & Unloading Sequence

Brief about loading and unloading sequence.

Phase	Description	Time Period
Phase - I	Commencement of load testing	0 hours
Phase - II	Start & completion of 50%, 75%, 90%, 100% of loading on the structure	On or before 24 hours after commencement of load test.
Phase - III	Retention of 100% load on the structure	24 hours.
Phase - IV	Start &completion of off loading structure in the sequence of 100%,90%, 75%, 50%, 0%	On or before 24 hours after completion of retention period of 100% load on the structure
Phase - V	Structure without any load	24 hours after complete off loading.

LOAD TESTING – CURRENT IRC STANDARDS

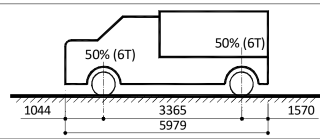
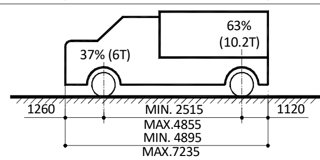
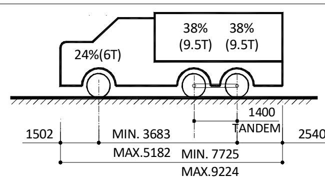
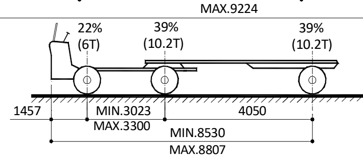
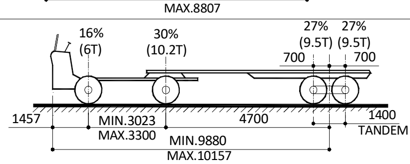
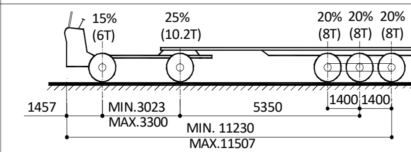
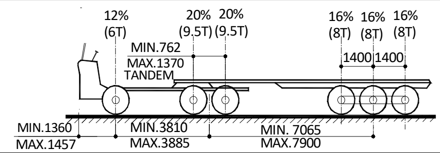
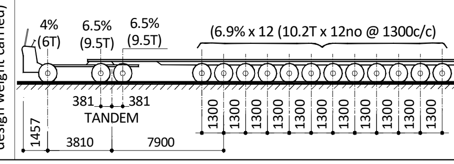


IRC:SP:37

- Deals with Load Testing for Rating and Posting
- Used as a means for acceptance of a bridge when it is not possible to determine rated capacity or to verify strength of bridge by analytical methods.
- For rating, standard IRC loading is used while for posting commercial vehicles as plying on the road is to be used.
- Test load position is to maximise moment. For Arch, specific load position specified.
- Testing for ULS not considered

LOAD TESTING – CURRENT IRC STANDARDS

Table-2 Classification of Commercial Vehicles

CLASSIFICATION OF COMMERCIAL VEHICLES										
Sr. No	TYPE Description	Type No.	Total No. of axles	Axle/Tyre Arrangement: Tractor Front End	Axle/Tyre Arrangement: Tractor Rear End	Axle/Tyre Arrangement: Trailor Rear End	Configuration & Distribution of Total Load (Nominal GVW)	Nominal GVW (Tonne)	Recommended Overload Factor	Standard Deviation
1	LIGHT VEHICLE	1					TWO WHEELERS. THREE WHEELERS PASSENGER AND GOODS VEHICLES			
2	RIGID LIGHT COMMERCIAL VEHICLE	2A	2	Axle: 1 Tyres: 2	Axle: 1 Tyres: 2	–		12.0	1.4	0.32
3	RIGID MEDIUM COMMERCIAL VEHICLE	2B	2	Axle: 1 Tyres: 2	Axle: 1 Tyres: 4	–		16.2	1.4	–
4	RIGID HEAVY COMMERCIAL VEHICLE	3A	3	Axle: 1 Tyres: 2	Axle: 2 Tyres: 8	–		25.0	1.4	0.29
5	ARTICULATED HEAVY VEHICLE (2 AXLE TRACTOR +1 AXLE TRAILOR)	3B	3	Axle: 1 Tyres: 2	Axle: 1 Tyres: 4	Axle: 1 Tyres: 4		26.4	1.4	0.32
6	ARTICULATED HEAVY VEHICLE (2 AXLE TRACTOR +2 AXLE TRAILOR)	4	4	Axle: 1 Tyres: 2	Axle: 1 Tyres: 4	Axle: 2 Tyres: 8		35.2	1.4	0.55
							MAX.10157			
7	ARTICULATED HEAVY VEHICLE (2 AXLE TRACTOR + 3 AXLE TRAILOR)	5	5	Axle: 1 Tyres: 2	Axle: 1 Tyres: 4	Axle: 3 Tyres: 12		40.2	1.4	–
8	ARTICULATED HEAVY VEHICLE (3 AXLE TRACTOR +3 AXLE TRAILOR)	6	6	Axle: 1 Tyres: 2	Axle: 2 Tyres: 8	Axle: 3 Tyres: 12		49.0	1.4	0.28
9	MULTI AXLE HEAVY VEHICLE	Multiaxle	15	Axle: 1 Tyres: 2	Axle: 2 Tyres: 8	Multiaxle 4 Tyres each no. of axle (depending on design weight carried)		147.4	Not Applicable	–

NOTES

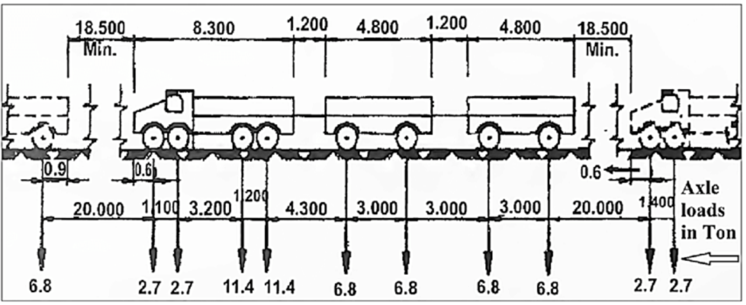
1 For Transverse spacing and types refer Fig. 2.

2 Recommended overload factors are based on recent surveys carried around in different cities on same stretches of National Highway/State Highway and are the mean overload factors. These can be modified as per local conditions.

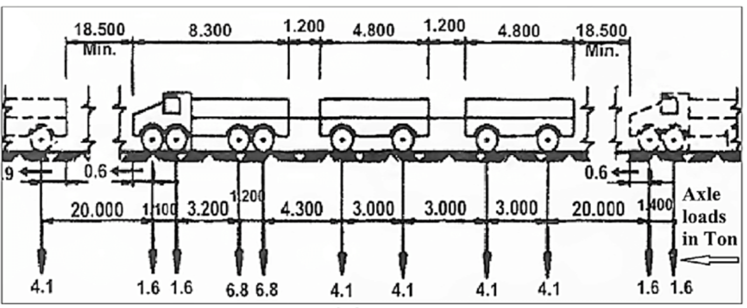
3 Overload factor for design checks can be taken as recommended in Table-2 for long span bridges likely to carry more then one GVW class vehicle under consideration for maximum live load effect.For small spans carrying one vehicle the LL/DL ratio is high and effect of LL should be checked for overload factor of (1.4+1.65x standard deviation)

LOADS TO BE USED FOR POSTING OF A BRIDGE

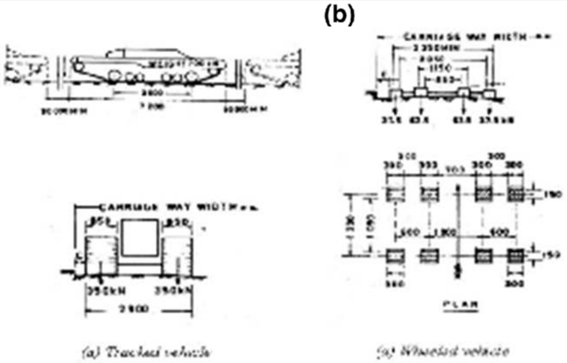
LOAD TESTING – CURRENT IRC STANDARDS



(a)



(b)



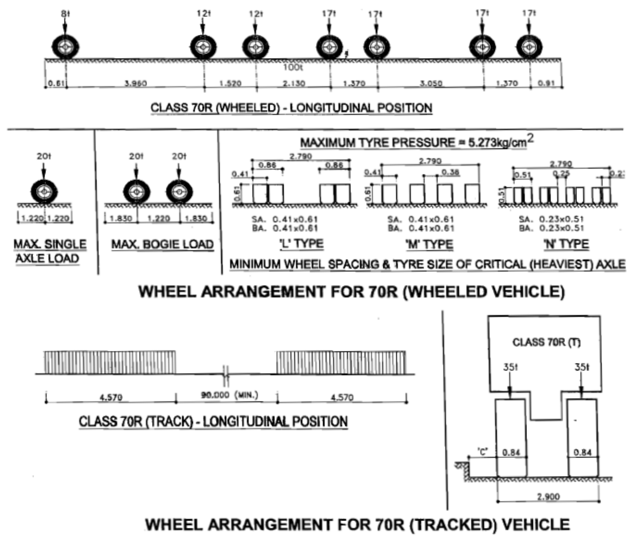
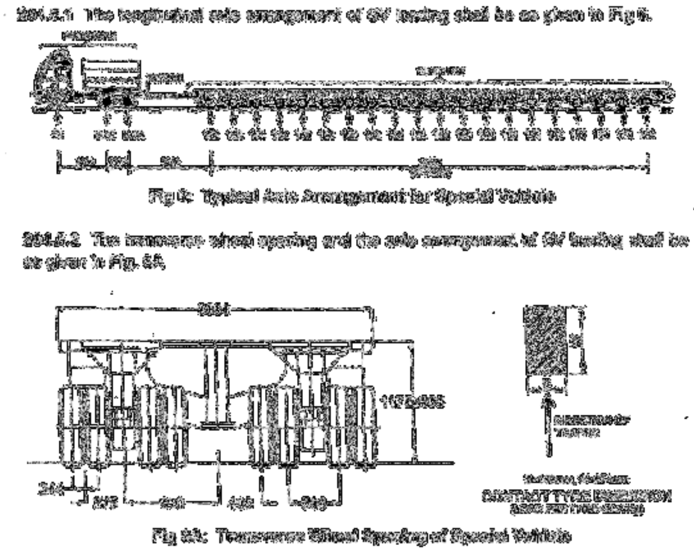


Fig. 1: Class 70 R Wheeled and Tracked Vehicles (Clause 204.1)

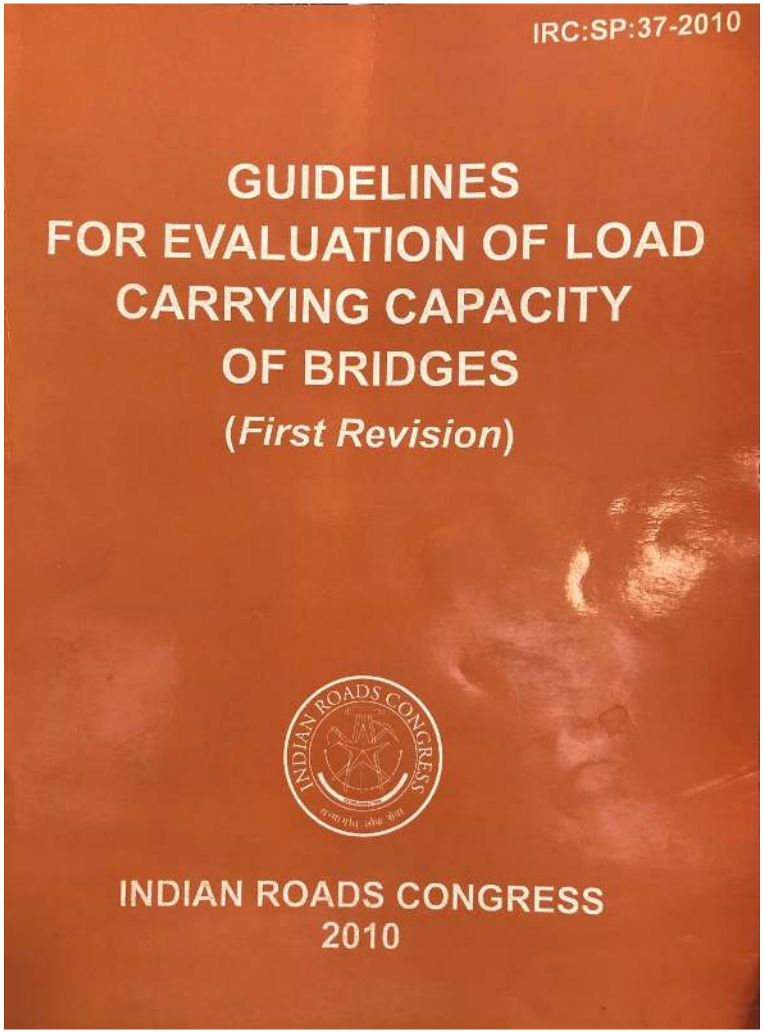


IRC HYPOTHETICAL LOADS :

CLASS – A, CLASS-B, CLASS 70R, CLASS AA & SV LOADING

LOADS TO BE USED FOR RATING OF A BRIDGE

LOAD TESTING – CURRENT IRC STANDARDS

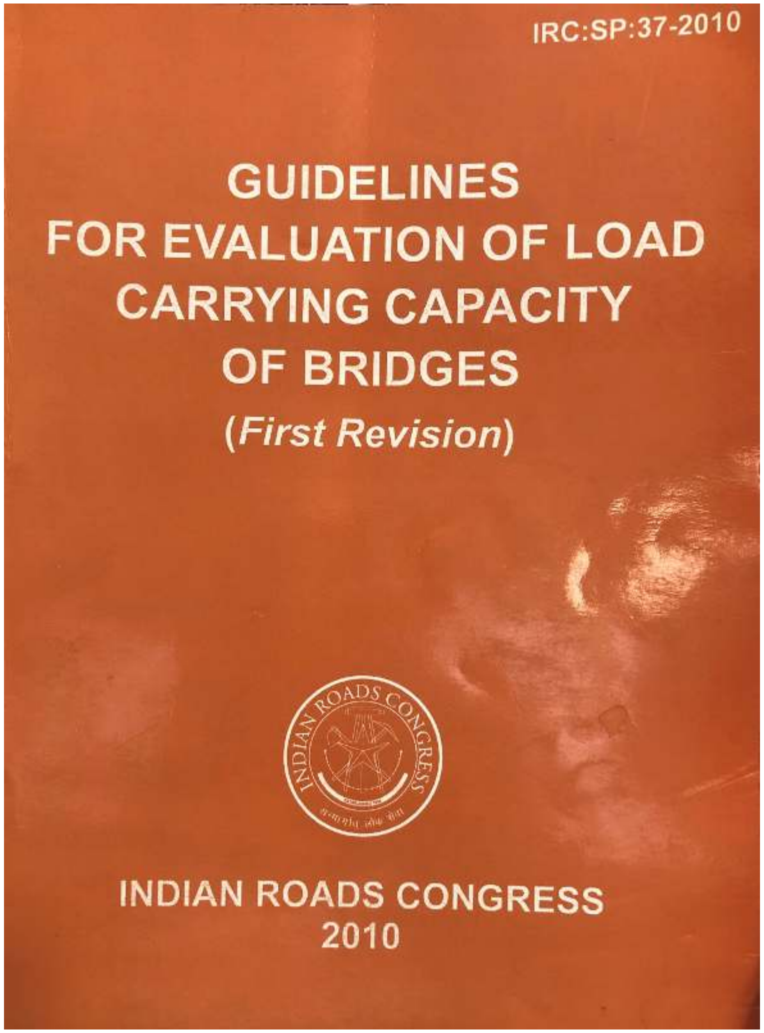


IRC:SP:37

Acceptance Criteria :

- Load causing a deflection of L/1500 for Simply Supported Span or L/800 for cantilever span
- Load causing tension crack / diagonal cracks of width 0.3mm / 0.2mm in any girder for Moderate / Severe environment respectively.
- % Recovery of Deflection @ 24 hours shall be not less than 75% (RCC & Composite) and 85% (PSC & Steel) Superstructures

LOAD TESTING – CURRENT IRC STANDARDS



IRC:SP:37 : Brief about Loading & Unloading Sequence

8.5.2 Prior to testing a whitewash shall be applied at the critical sections for ease of observation of behaviour of cracks and their new formations during the test.

8.5.3 The load test shall be done during such period of the day when the variation in temperature during test is low. Preferably, the testing could be done in early hours of morning or late evening.

8.5.4 The test load shall be applied in stages following the given values 0.5W, 0.75W, 0.90W, 1.0W, where "W" is the gross laden weight of the test vehicle.

8.5.5 For each stage, the correspondingly loaded test vehicle shall be brought to the intended/marked position and observation of deflections shall be made immediately on loading and after five minutes.

The test vehicle should be taken off the bridge and instantaneous deflection recovery and deflection recovery 5 minutes after the removal of the load should be noted.

8.5.6 After the load placement, observation shall also be made for development of any new crack and widening of the existing ones.

LOAD TESTING – CURRENT IRC STANDARDS

LOAD TESTING – CURRENT IRC STANDARDS

OVERVIEW OF THE PRESENTATION

1. Introduction
2. Load Testing – Current IRC Standards
3. **Appraisal of the IRC Standard on Load Testing**
4. Summary & Conclusions

APPRAISAL OF IRC STANDARDS ON LOAD TESTING

1. At present the Indian codes lay emphasis only on measurement of deflection under a stated unfactored service load, in both static and dynamic format.
2. Deflection is a serviceability criteria and only indicates the stiffness of the structure, and dependent on the Flexural Rigiidity …‘EI’ value.
3. For Arch Bridges, deflection is not the criteria for assessing its load bearing capacity

4. **What is more important for understanding the health of a structure is:**
   a. What is the reserve capacity of the structure ?
   b. whether the structure is behaving as per the design assumptions ?
   c. whether the material properties are in their original stage and fulfils the design specification & if it is possible to assess
   d. the future properties of the materials over time scale-for assessing the residual life.

5. **As of now this part is not covered in Indian codes at all. Even if there is provision of measuring the stress by use of strain gauges, currently no emphasis is given on this aspect.**

OVERVIEW OF THE PRESENTATION

1. Introduction
2. Load Testing – Current IRC Standards
3. Appraisal of the IRC Standard on Load Testing
4. **Summary & Conclusions**

SUMMARY & CONCLUSION

1. Indian Load Testing standard requires updating. It should be in line with the international practice.
2. There should be a single guideline on load testing.
3. Objective & goals of load testing shall be made clear in the code.
4. There should be proper guideline for load testing preparation & instrumentation. Its important to instrument the bridge well so that one can study the behaviour well.

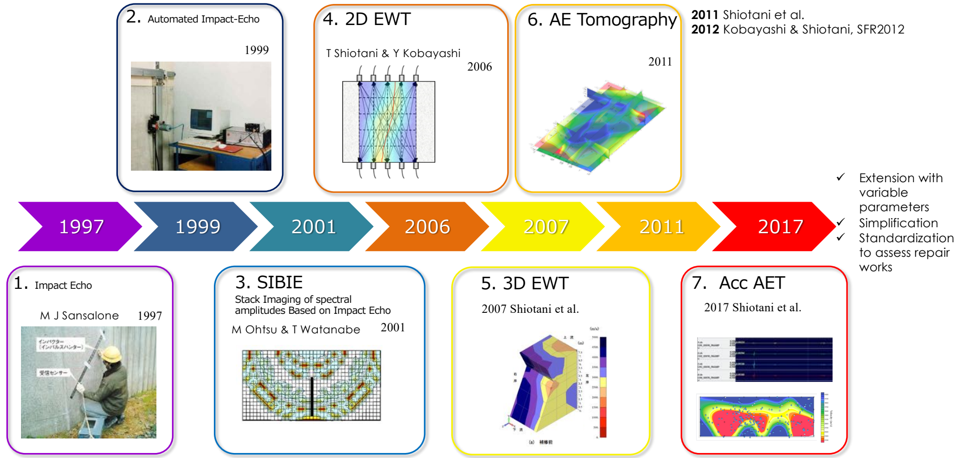
Thank you for your Patience

For any query, may contact me at : bsec.ab@gmail.com

Assessment of bridge deck performance with overall elastic wave velocity - Case study before/ after repair works -

Tomoki Shiotani
Kyoto University

Brief history of elastic wave techniques for concrete




International Union of Laboratories and Experts in Construction Materials, Systems and Structures

2019 2020 Technical Report

269-IAM

Damage assessment in consideration of repair/retrofit-recovery in concrete and masonry structures by means of innovative NDT

Chair Tomoki SHIOTANI
Deputy Chair Dimitrios AGGELIS
Activity started in 2016

Combined use of Digital Image Correlation and AE source localization for crack detection and characterization. Courtesy of MEMC-VUB.

TC members in Turin, Italy, at the 7th meeting. Courtesy of Tomoki Shiotani.

Significance
Worldwide infrastructure is aging. Proper condition evaluation and maintenance are essential. There is an urgent necessity to change maintenance from "reactive" to "proactive" as the latter requires less budget.

Relevance
• Targeted users are construction and maintenance industries, owners/managers of infrastructure, a broad range of stakeholders.
• Better use of resources and increased safety and reliability will benefit society.

Goals
• Exploring effective NDT techniques to use in structures.
• Quantifying the repair effect.
• Improving reliability of repair and monitoring methods.
• Establishing life cycle scenarios considering repair improvement as obtained by NDT techniques.
• Publishing RILEM recommendations and recommended practices for quantification of repair/ reinforcement works by NDT; workshop proceedings, possibly as a special issue of Materials & Structures, State-of-the-Art Report (STAR).
• Organising training courses for one-site measurement by NDT.
• Submitting pre-standards to ISO.

Methodology
• Studies of repair practices in different countries.
• Organization of "task forces" focused on:
1. Survey (suitable NDT methods).
2. Evaluation of initial damage.
3. Evaluation of repair.
4. Life cycle management in relation to 3.

Progress
• Seven meetings have taken place so far.
• Preliminary discussion on the assignment of task force topics has taken place in the last meeting.
• Discussion about distribution of chapters of STAR to TC members will be done in the next months.

Progress:

- 1st mtg: 18th of May 2016, @ Radisson Blu Hotel Edinburgh, **Edinburgh, Scotland, UK**
  - Attendance: 9 members, 8 guests
- 2nd mtg: 9th of Dec 2016, @ Kyoto Tersa, **Kyoto, Japan**
  - Attendance: 16 members, 3 guests
- 3rd mtg: 15th of Sep 2017 @ Universite Libre de Bruxelles, Solbosch campus, Building R42, **Brussels, Belgium**
  - Attendance: 13 members, 3 guests
- 4th mtg: 17th of May 2018 @ Radisson Blu Hotel Edinburgh, **Edinburgh, Scotland, UK**
  - Attendance: 10 members, 3 guests
- 5th mtg: 8th of Nov 2018 @ Sapporo Education and Culture Hall, **Sapporo, Japan**
  - Attendance: 11 members, 5 guests
- 6th mtg: 19th of March 2019 @ Hotel Lone, **Rovinj, Croatia**
  - Attendance: 4 members, 3 guests
- 7th mtg: 28-29th of Oct 2019 @ Stanza dei Gigli, Politechnico di Torino, **Turin, Italy**
  - Attendance: 10 members, 12 guests
- **8th mtg: 15th April 2021, @ Zoom virtual meeting,**
  - **Attendance: 21 members, 2 guests**
- 9th mtg: Late of 2021, @ Zoom virtual meeting

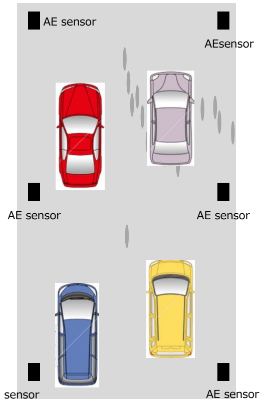
RELEVANT WORKSHOP WILL BE ORGANIZED IN 76TH RILEM WEEK IN KYOTO, SEP, 2022.

Outcome from TC (planned):

- **STAR will be published.**
- **2 RILEM Recommendations will be published.**

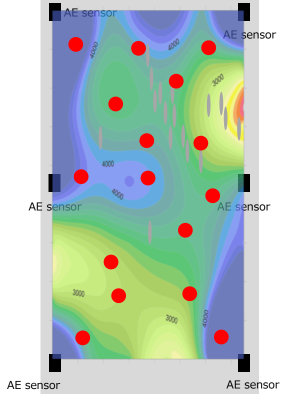
https://rilemweek2022.jp

AE monitoring



Real-time evaluation of progressive failure_ locations, scale..
★ continuous monitoring

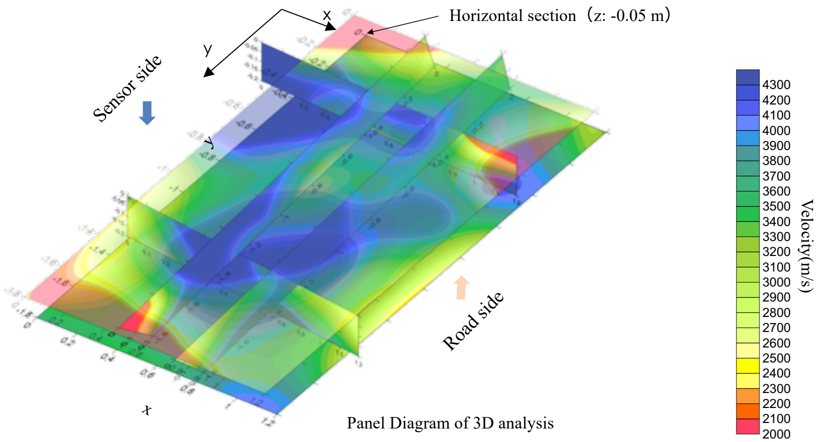
AE tomography
(Tomography with source location)



Present evaluation on cumulative past-failure_locations, degree
★ On-demand time monitoring

Laboratory on Innovative Techniques for Infrastructures (ITIL)

Results of AE Tomography (3D)

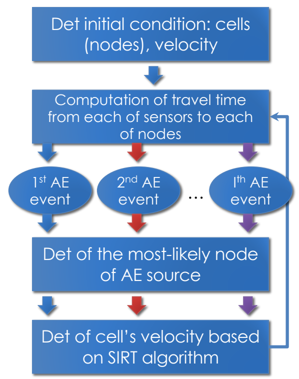


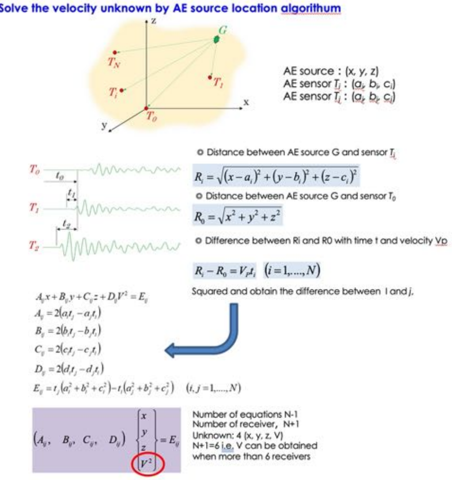
Laboratory on Innovative Techniques for Infrastructures (ITIL)

Brief procedure of 2D AE Tomography

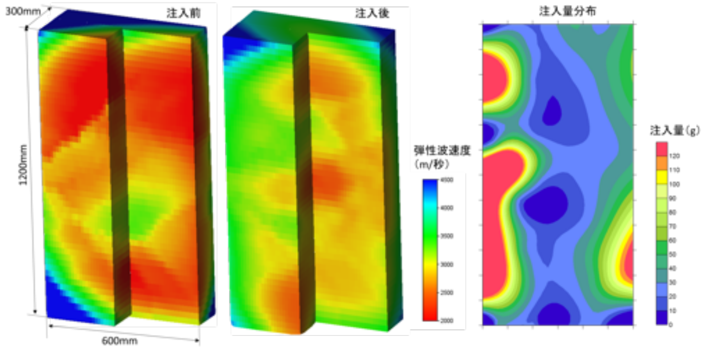
Solve the velocity unknown by AE source location algorithum

Kobayashi, Y. and T. Shiotani (2012), Seismic Tomography with Estim ***Faults and Repair 2012****, Edinburgh.*



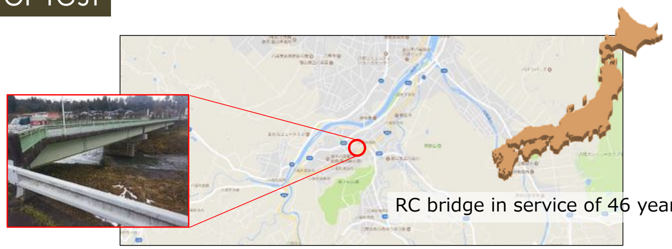


Application for assessment of repair program, case study on surface crack injection



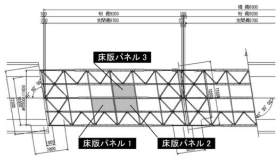
Before injection | After injection | Volume of injection agent

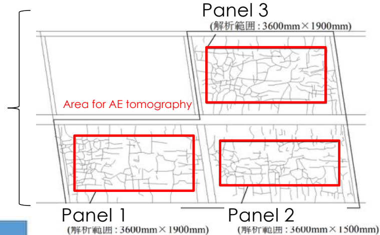
Bridge for test

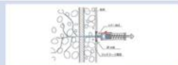
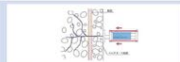


形　式	Non-composite beams, 3 spans
Length	88.0m
age	46 years
Thickness of deck	Concrete 200 mm+ Asphalt 50 mm
Surface condition	Remarkable mesh patterned cracks, presumably caused by ASR on the bottom

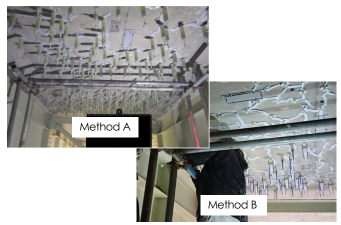
3 panels tested & Repair methods





	For Panel 1 &2	For Panel 3
工法	 Method A	 Method B
概要	コンクリート表面を削孔・シールし、エアー抜きを伴いながら低圧注入する。低粘度、長時間をかけて注入するため微細な空隙まで注入が期待できる。	ひび割れ表面をシールし、専用注入台座と注入器でエポキシ樹脂を低圧注入。樹脂を押込む注入であるため微細部への侵入が不足
充填材	Epoxy agent Type1 Viscosity 500±200mPa・s	Epoxy agent Type 3 Viscosity 600±100mPa・s
加圧方式	Spring pressure →エア抜き機能を有し スプリングの反発力により低圧注入	Rubber band pressure →注入器に備えたゴムの復元力により加圧
加圧力	初期：0.06N/mm2 安定時：0.02N/mm2	初期：0.4N/mm2 安定時：0.098N/mm2

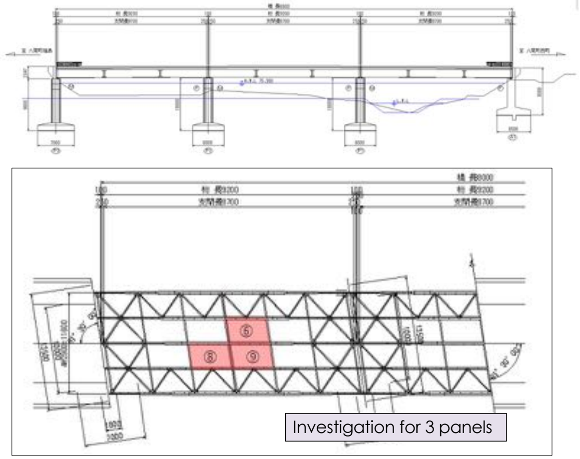
※新日本コンサル



Surface crack injection by epoxy

Objective concrete deck

橋長88m



Visual inspection

Mesh type cracks developed
➡ fatigue ＋ ASR combined deterioration

For repair quantification

- **Three approaches before after repair**
  - Elastic wave velocity: V
    - AE tomography
  - Mechanical behavior: $\delta_{measurement}$
    - Central deflection by proof loads
  - Response simulation: $\delta_{simulated}$
    - multiscale analysis program, DuCOM-COM3

V vs δ

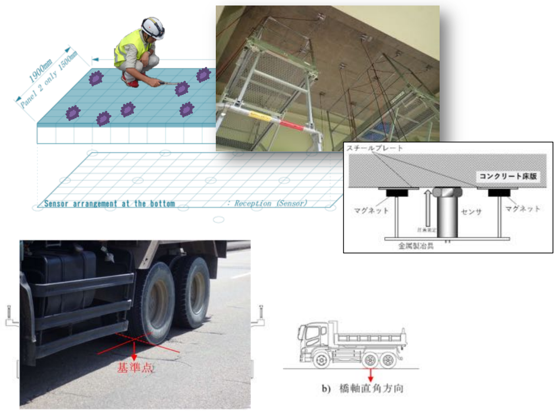
$\delta_{Measurement}$ vs $\delta_{simulated}$

Laboratory on Innovative Techniques for Infrastructures (ITIL)

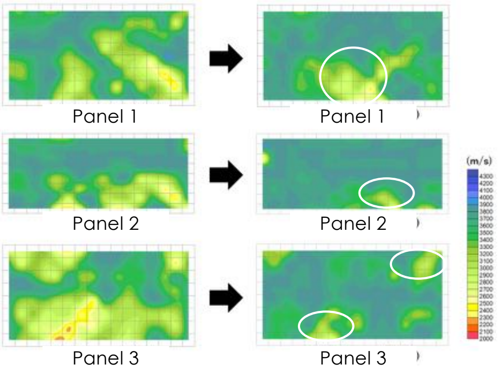
Experimental condition

Before/ After repair

- Elastic velocity
  - ✓AE tomography
- Central deflection
  - ✓Proof loading by dump truck of 20 tons



Velocity distributions



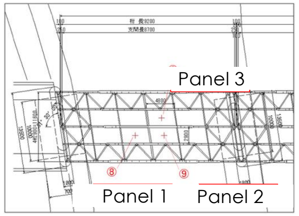
Concrete quality table by Whitehurst

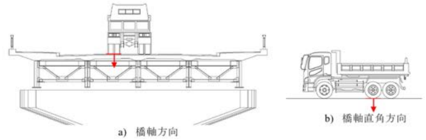
P波速度　Vp [m/s]	Quakity
＞4570	Excellent
3660－4570	Fine
3050－3660	Acceptable
2130－3050	Un-acceptable
＜2130	Poor

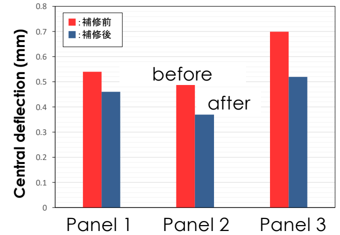
Ref.: E.A. Whitehurst : Evaluation of concrete properties from sonic tests, ACI Monograph No.2, ACI, 1966

Un-acceptoble areas found after repair

Results of proof load test





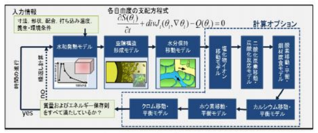


Laboratory on Innovative Techniques for Infrastructures (ITIL)

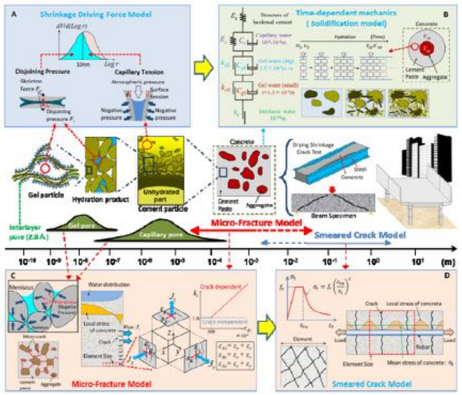
Response simulation by multiscale analysis program, DuCOM-COM3

東京大学 THE UNIVERSITY OF TOKYO　KIT 金沢工業大学

Prof. Y. Tanaka

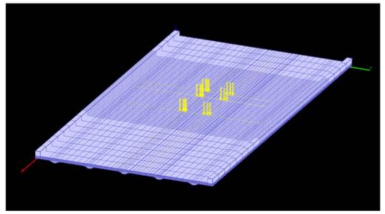


コンクリートの微細空隙中に腐食ゲルが入り込むことによる膨張圧力の低下（Buffer Effect）も考慮可能



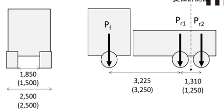
Laboratory on Innovative Techniques for Infrastructures (ITIL)

Modeling & 3 types of deteriorations



■ Mechanical properties of bridge deck

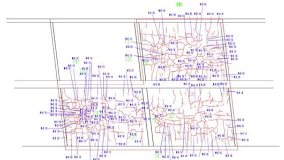
項　目		物性値
concrete	Compression strength	240 kg/cm²
	Elastic modulus	250,000 kg/cm²
rebar	Elastic modulus	2,100,000 kg/cm²
	Yield strength	2,950 kg/cm²



1 Fatigue loads

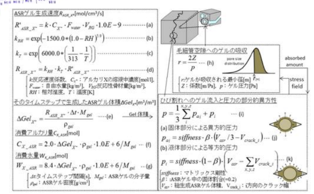
Wheel loads & mobile load cycles by fixed-route bus, 15 passages a day i.e., 125 thousands cycles

2 Actual cracks

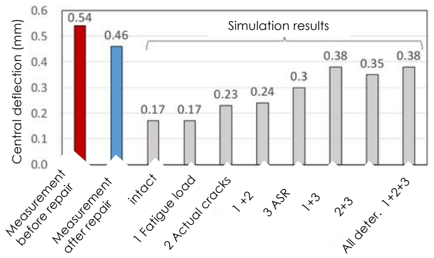


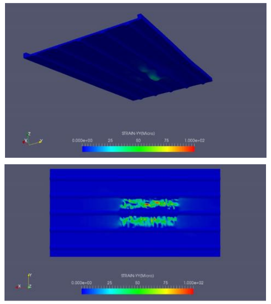
3 ASR gel

Modeled by
Y. Takahashi, Y. Tanaka, K. Maekawa, Computational Life Assessment of ASR-damaged RC Decks by Site-Inspection Data Assimilation, Journal of Advanced Concrete Technology, volume 16, pp.46-60, 2018.

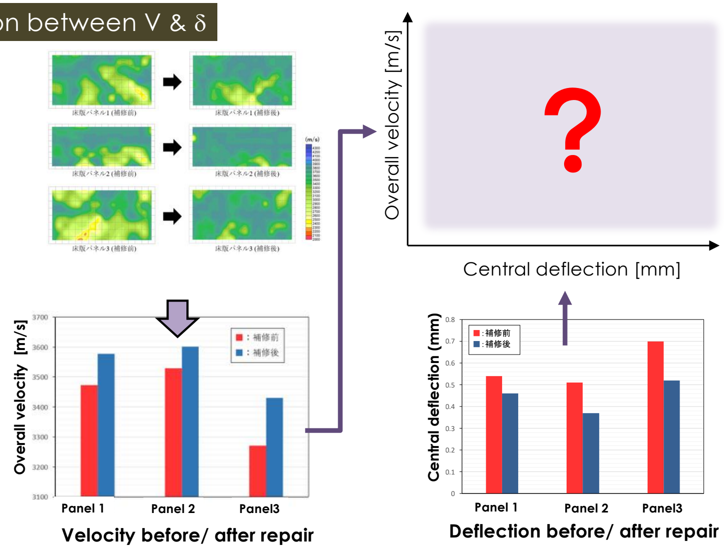


Results of Panel 1





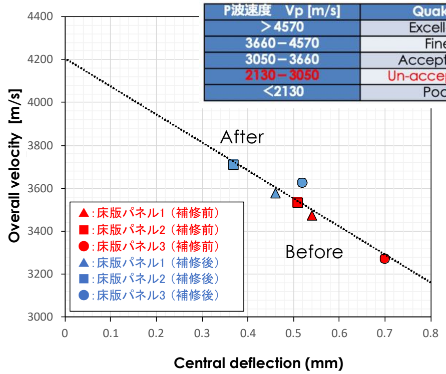
Relation between V & δ

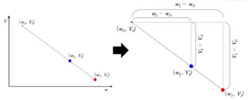


弾性波速度とたわみの関係

Concrete quality by EW velocity, 1966 Whitehurst

P波速度　Vp [m/s]	Quakity
＞4570	Excellent
3660－4570	Fine
3050－3660	Acceptable
2130－3050	Un-acceptable
<2130	Poor





$$\frac{V_2 - V_0}{V_1 - V_0} = \frac{w_2 - w_0}{w_1 - w_0}$$

V_0: velocity of intact, w_0:def of intact
V_i: i^{th} cond velocity, w_i: i^{th} cond deflection

$$D_d = \frac{w - w_0}{w_c - w_0}$$

D_d: Deg damage, w_0: def of intact
w_C: def of critical state, w: measurement def

V_C: Vel of critical state

From those equations

$$\frac{V_2 - V_0}{V_1 - V_0} = \frac{D_2}{D_1}$$

$D_V=(V-V_0)/(V_C-V_0)$

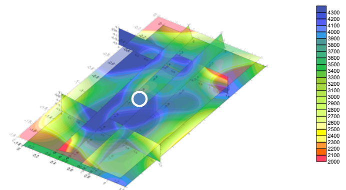
Take away

1) Real/Actual deformation was difficult to estimate by simulation analysis so that difficult to quantify the damage or repair effect.
2) By combining overall velocity and deformation, a good relation was found between them and in consideration of velocity when un-acceptable condition, the damage or repair effect could be quantified by Dv obtained from velocities of current and that of un- acceptable condition.

$$V_p = \sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}}$$

$$V_s = \sqrt{\frac{E}{2(1+\nu)\rho}}$$

■ Velocity obtained by E and …



■ Using overall velocity is a KEY!!

Thanks

shiotani.tomoki.2v@kyoto-u.ac.jp

http://iti-labo.kuciv.kyoto-u.ac.jp

https://citi.kuciv.kyoto-u.ac.jp

Digitally twinned load tests in railway bridges.

Bits and pipelines to a Standard. The Ashvin contribution

Rolando Chacón

Department of Civil and Environmental Engineering
Universitat Politècnica de Catalunya

ASHVIN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958161

“Bridge load testing can answer a variety of questions about bridge behavior that cannot be answered otherwise”

Alampalli et al. 2021. Bridge load testing. State-to-the-practice
Journal of Bridge Engineering

“It can be realized that by providing confirmative information on structural capacity, a load test can reduce the probability of failure of a bridge”

Alampalli et al. 2021. Bridge load testing. State-to-the-practice
Journal of Bridge Engineering

“This increased confidence in structural safety can be converted to an economic benefit using risk analysis”

Alampalli et al. 2021. Bridge load testing. State-to-the-practice
Journal of Bridge Engineering

Better understanding of the behavior

Reduced probability of failure

Economic benefit assessed with risk analysis

Better understanding of the behavior

Reduced probability of failure

Economic benefit assessed with risk analysis

Economic benefit related to new digital needs

Ashvin

Assistants for Healthy, Safe, and Productive Virtual Construction Design, Operation & Maintenance using a Digital Twin

ASHVIN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958161

Ashvin

Assistants for Healthy, Safe, and Productive Virtual Construction Design, Operation & Maintenance using a Digital Twin

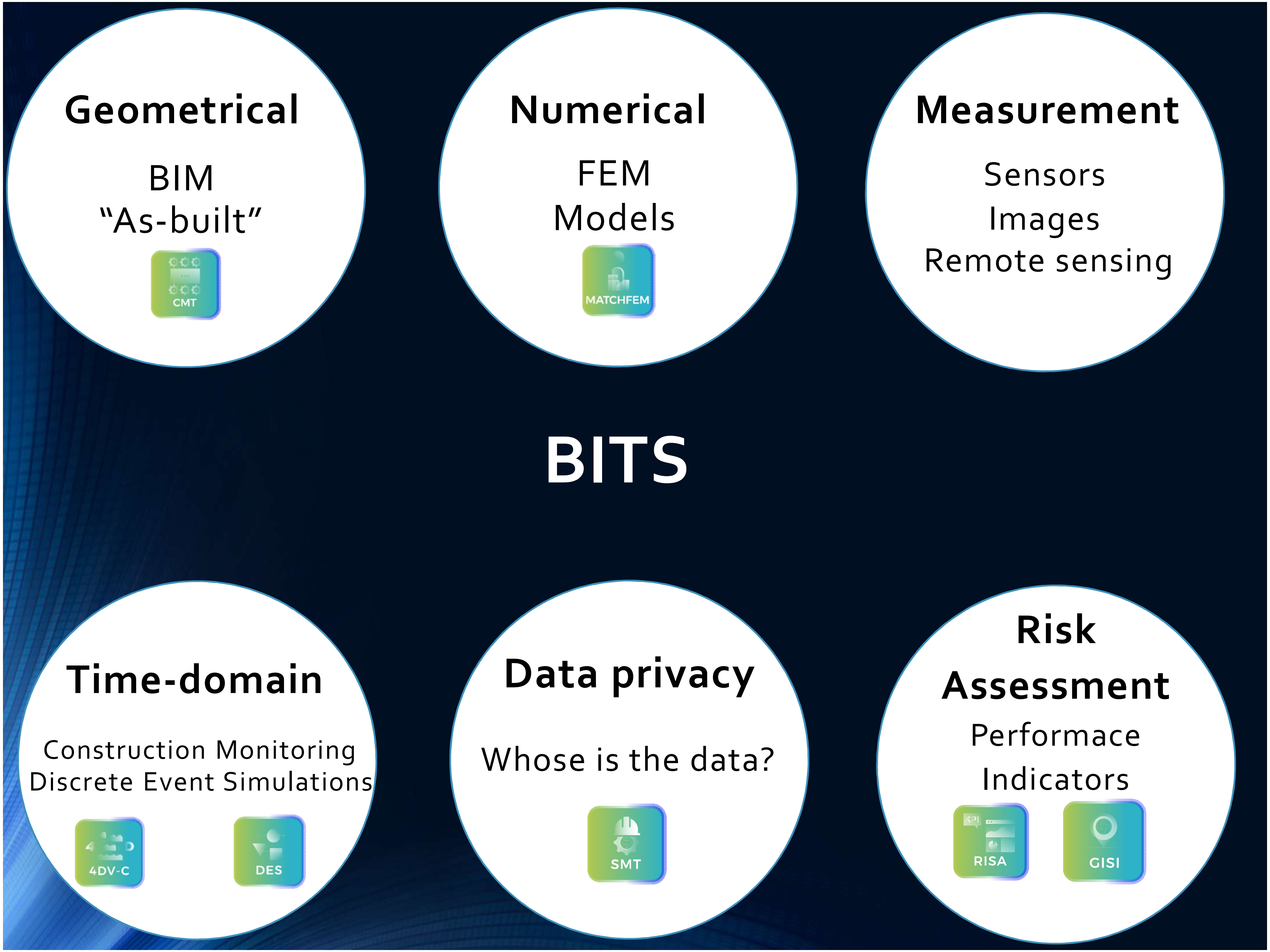
ASHVIN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958161

ASHVIN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958161

Design

Construction

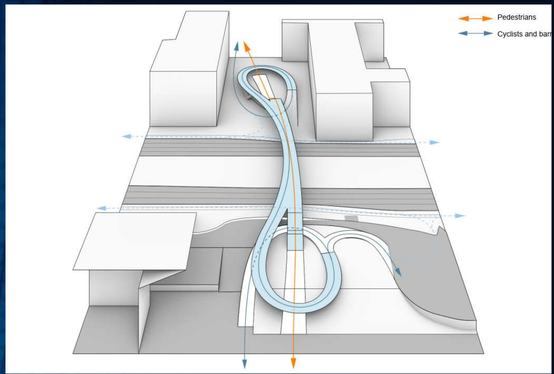
Maintenance


Geometrical
BIM
“As-built”
CMT
Numerical
FEM
Models
MATCHFEM
Measurement
Sensors
Images
Remote sensing
BITS
Time-domain
Construction Monitoring
Discrete Event Simulations
4DV-C
DES
Data privacy
Whose is the data?
SMT
Risk
Assessment
Performace
Indicators
RISA
GISI

Railway bridges, Spain

House refurbishing, Poland

Zadar Airport, Croatia

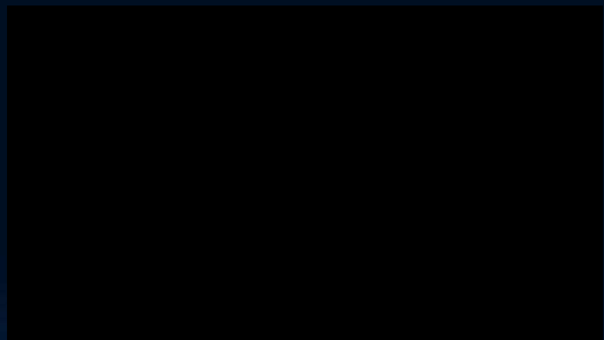


Footbridge, Germany

Building construction, Sweden

Stadium, Germany

Roadway bridge, Spain

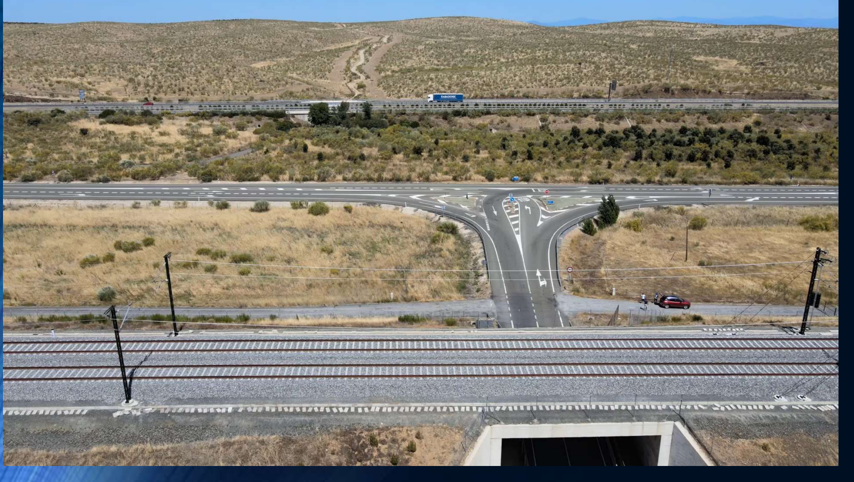


Building construction, Spain

Port of Rotterdam, The Netherlands

Simply supported Beams
Viaducto de Valdelinares

Continuous beam
Viaducto de la Plata



Underpass
PK 1050

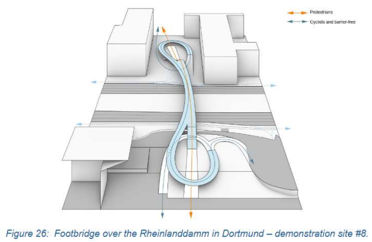
Arch bridges
El Tajo and Almonte Viaducts

Demosite 1. Load tests in railway bridges. Spain

The bridges that are designed today in most parts of the world are not fully conceived for a maintenance scenario of year 2041

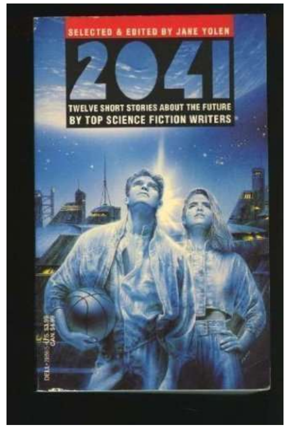
2001

Lleida, Spain
P-Delta

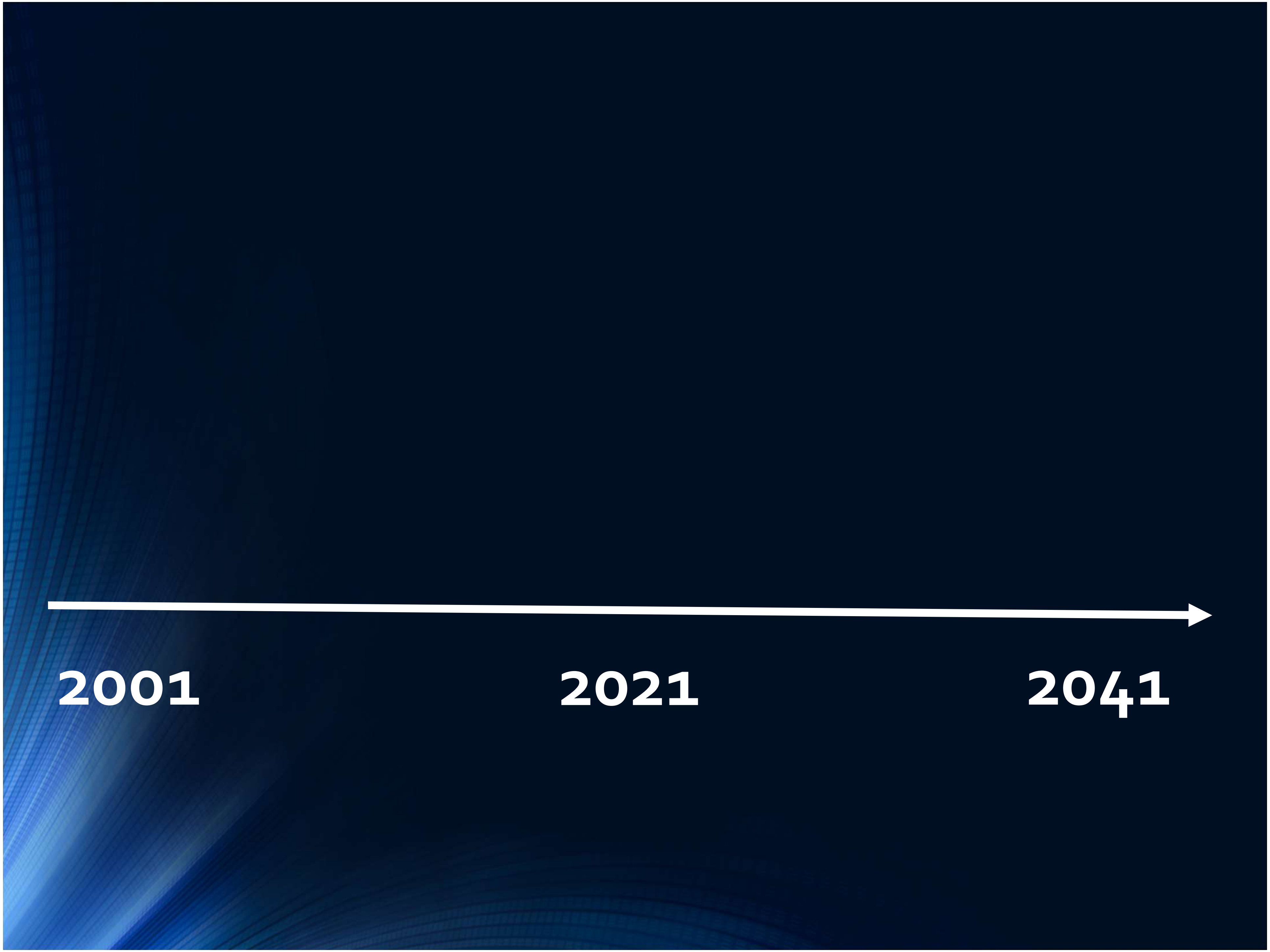


2021

Dortmund, Germany
Schlaich Bergerman Partner



2041


2001
2021
2041

Will the 2041 maintenance scenario expect a highly digitalized asset?

When will we/they generate it?

Digitalization?

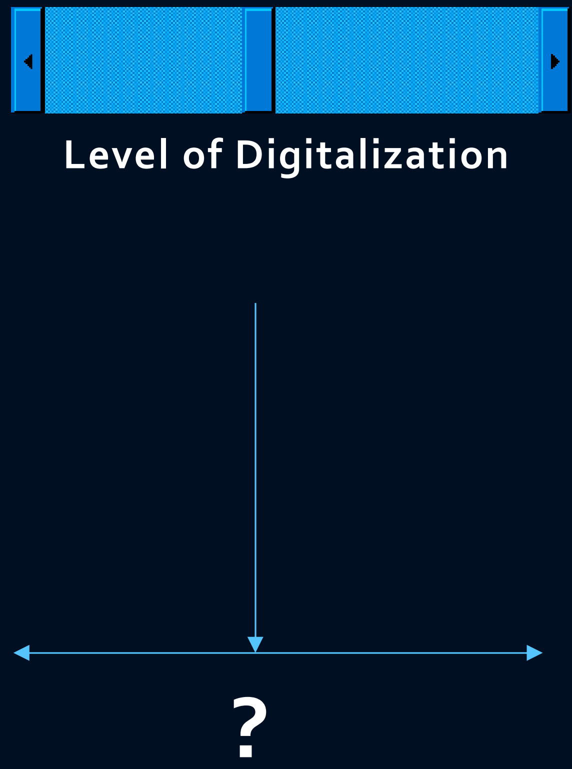
When?

?

2001 **2021** **2041**

Will the 2041 maintenance scenario expect a highly digitalized asset?

What level of virtualization of the assets will we/they have?

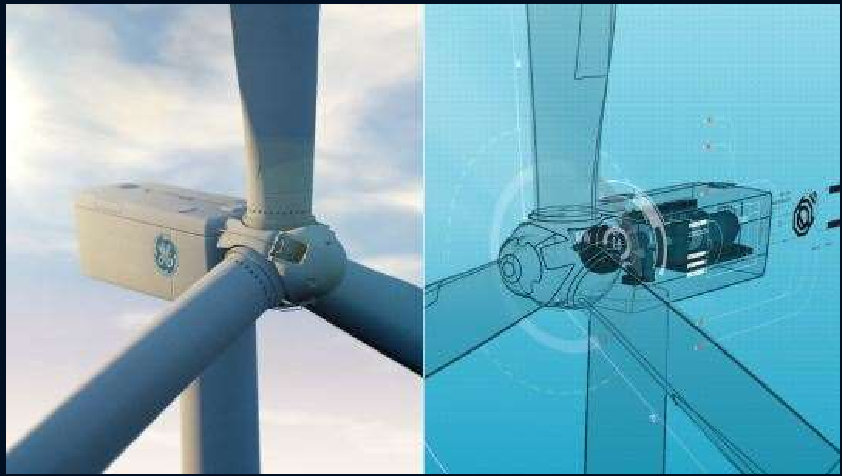


2001 **2021** **2041**

Digital Twins

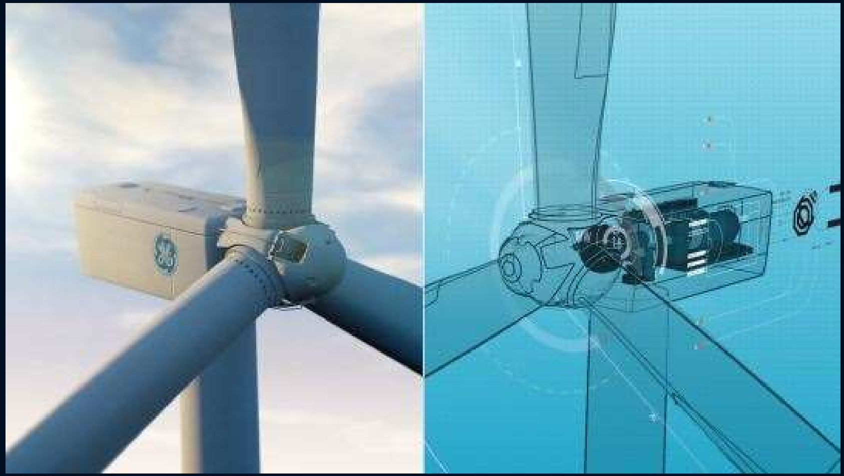
Digital twin refers to a digital replica of physical assets, processes and systems

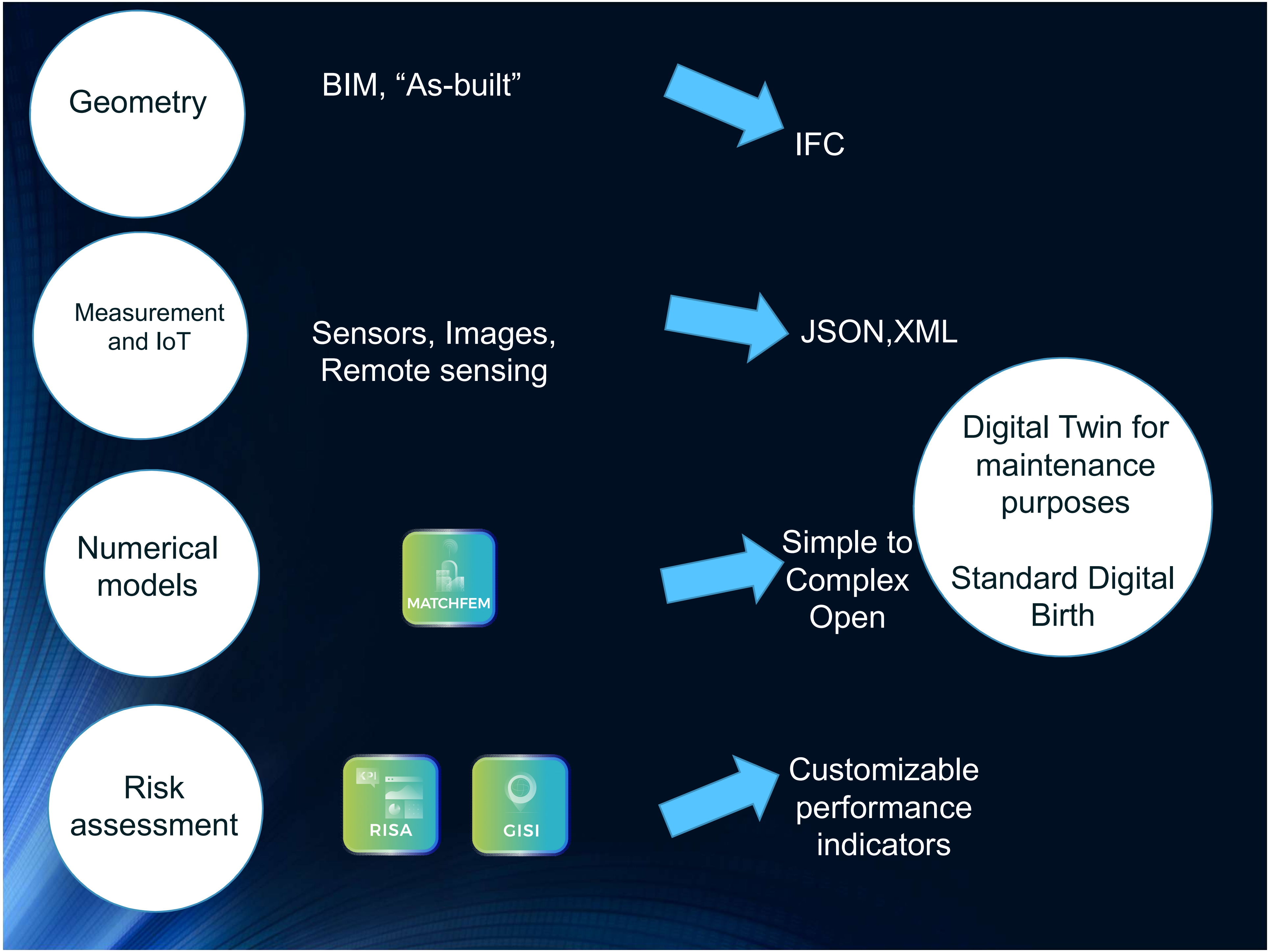
The digital representation provides both the elements and the dynamics of how **Internet of things** and **Structural Health Monitoring** devices operate and live throughout their life cycles



Digital Twins

Define the bits and the pipelines




Geometry
BIM, "As-built"
IFC
Measurement and IoT
Sensors, Images, Remote sensing
JSON,XML
Digital Twin for maintenance purposes
Standard Digital Birth
Numerical models
MATCHFEM
Simple to Complex Open
Risk assessment
KPI
RISA
GISI
Customizable performance indicators

A Coruña
Gijón
Santander
Bilbao
Donostia-San Sebastian
Toulouse
Montpellier
Cannes
Aix-en-Provence
Marseille
Santiago de Compostela
Oviedo
Vigo
Andorra
Girona
Pamplona
Valladolid
Zaragoza
Barcelona
Porto
Salamanca
Tarragona
Aveiro
Madrid
Coimbra
Castellón de la Plana
Balearic Sea
Toledo
Portugal
Valencia
Spain
Lisbon
Ibiza
Palma
Badajoz
Benidorm
Córdoba
Murcia
Alicante
Seville
Albufeira
Granada
Algiers
مدينة الجزائر
Almería
Faro
Marbella
Gibraltar
Batna
Alboran Sea
Tangier

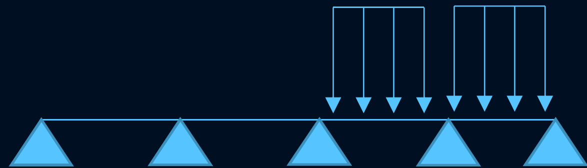
Load Tests

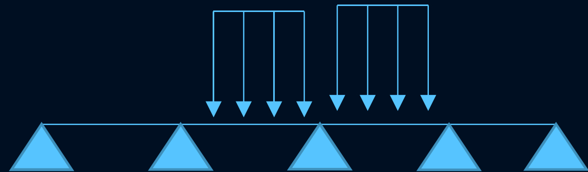
Extremadura, Spain.
Ashvin demosite #1.
Viaducto de la Plata

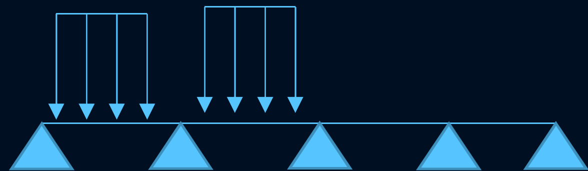
Load Tests

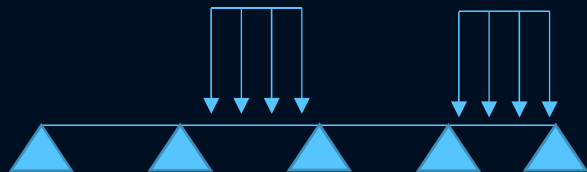
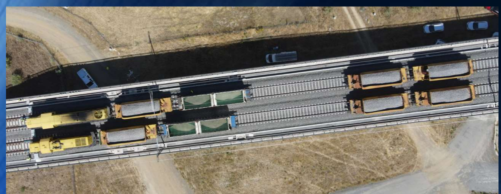
Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata

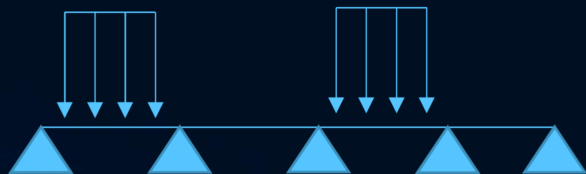




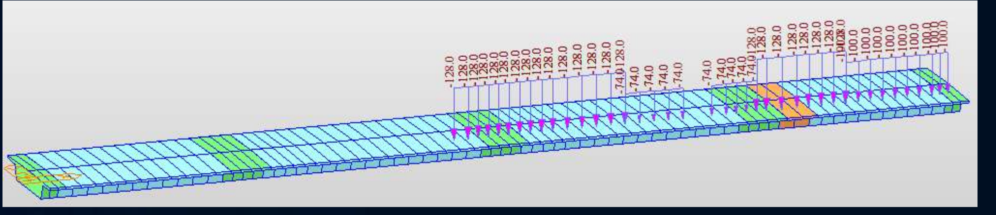



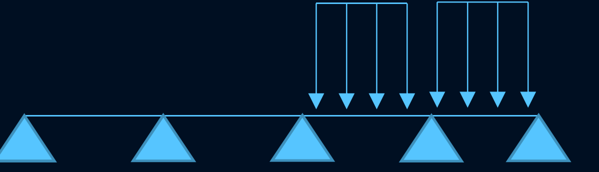




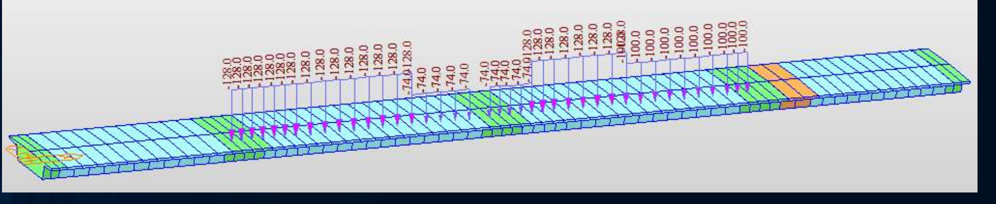


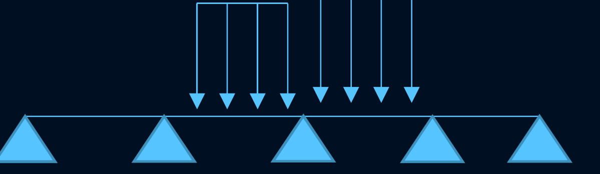
Load Tests

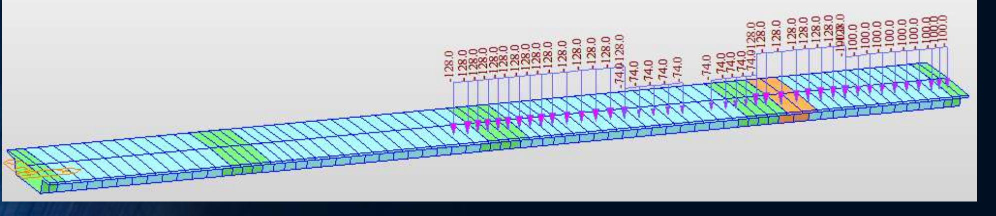
Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata

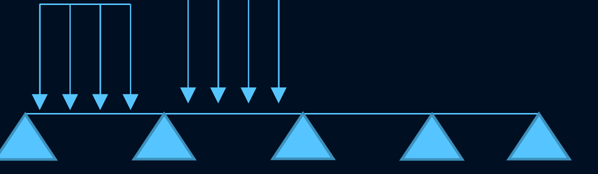


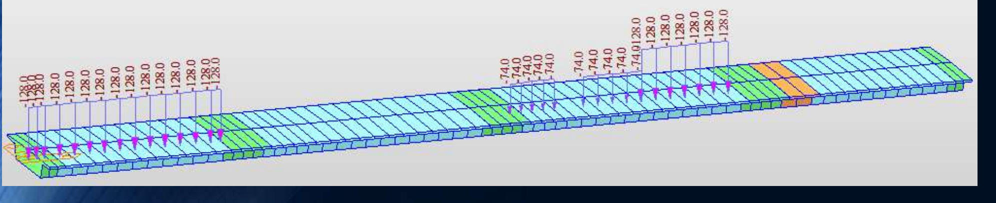


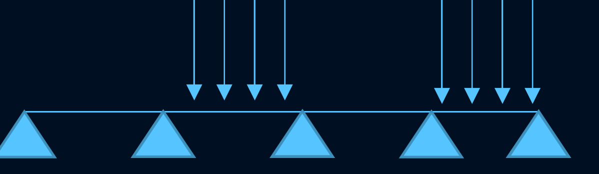


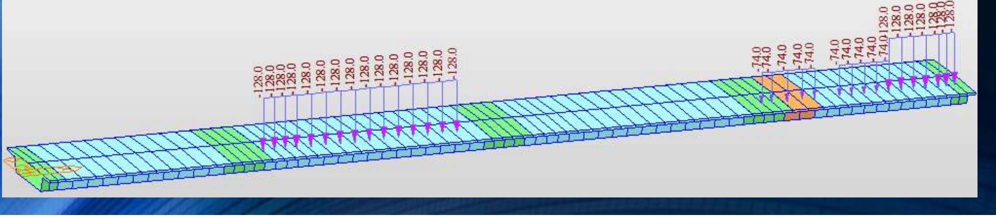


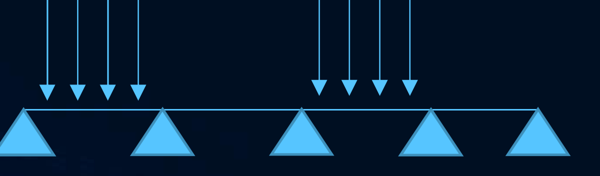






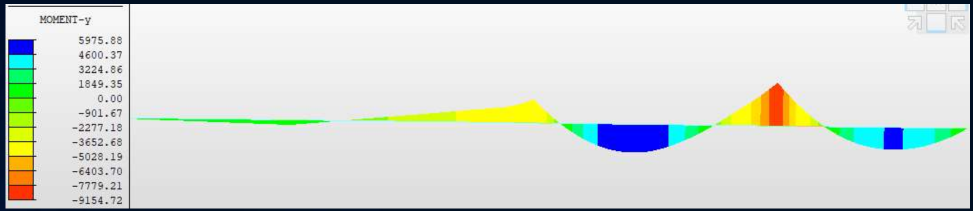


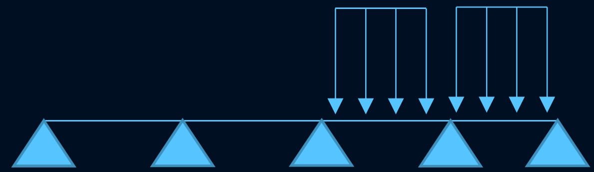


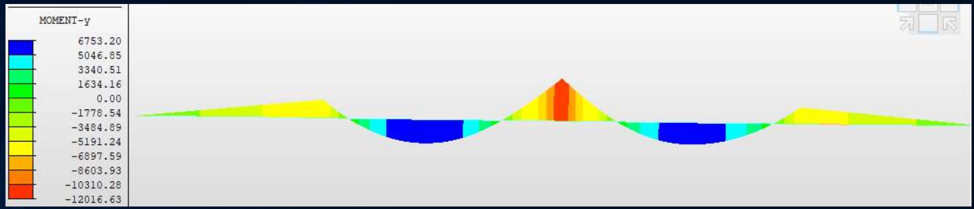


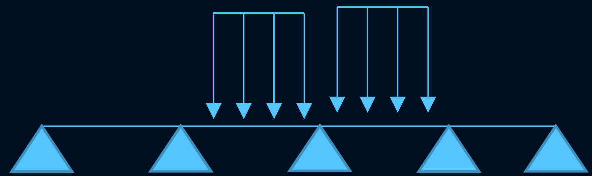
Load Tests

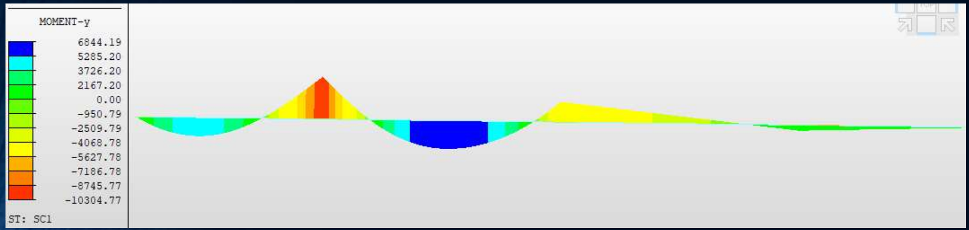
Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata

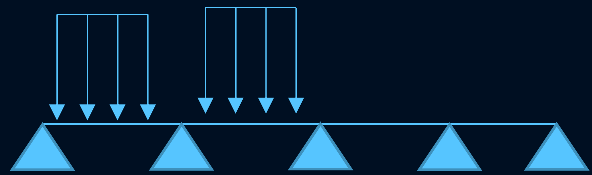


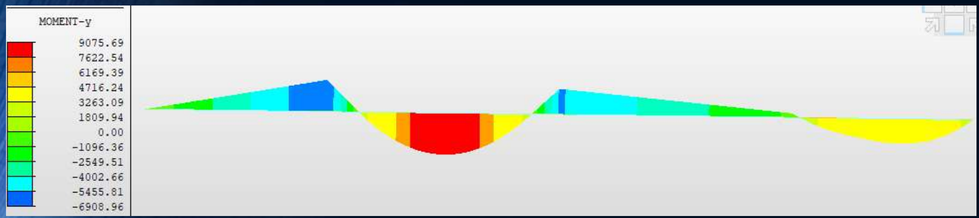


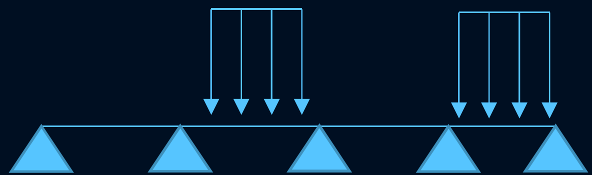


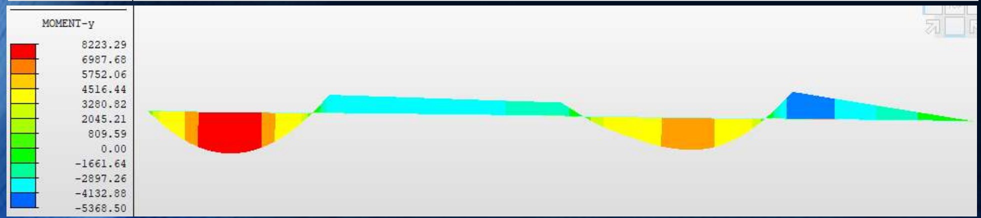


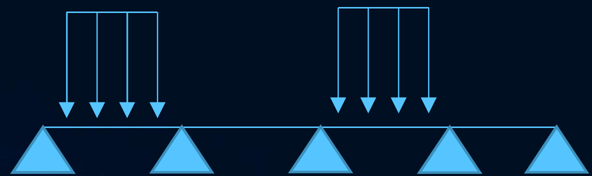






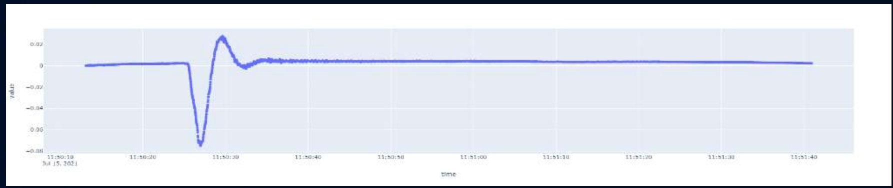


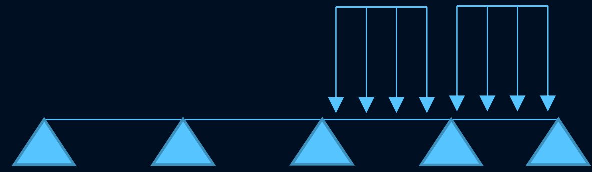


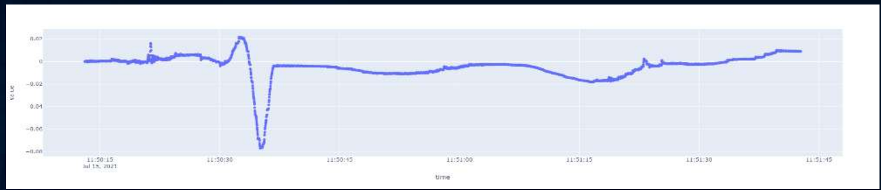


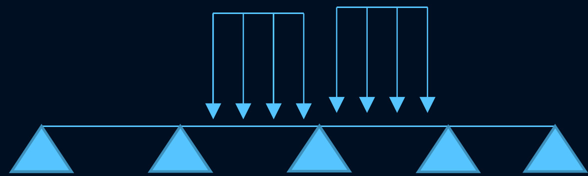
Load Tests

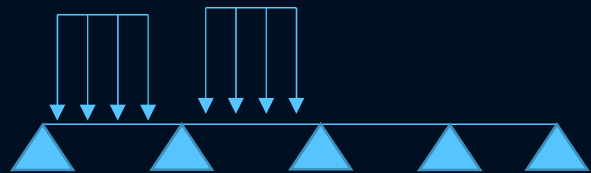
Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata

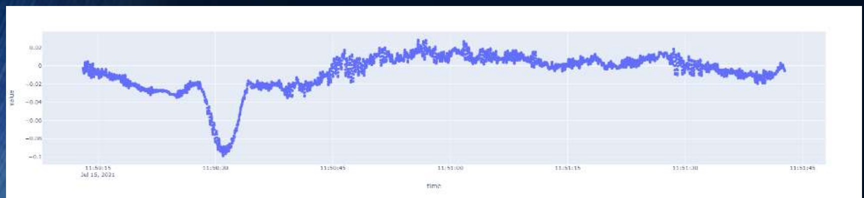


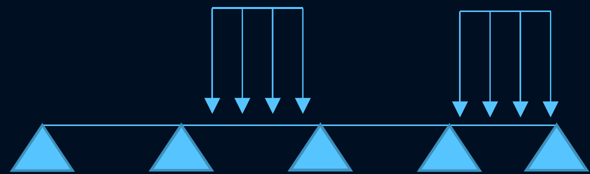


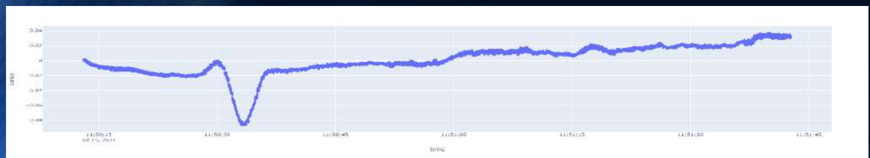


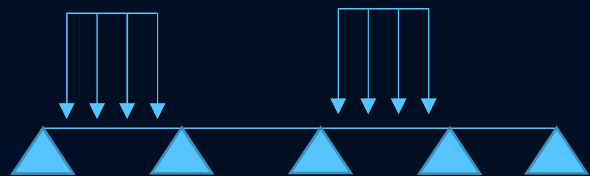






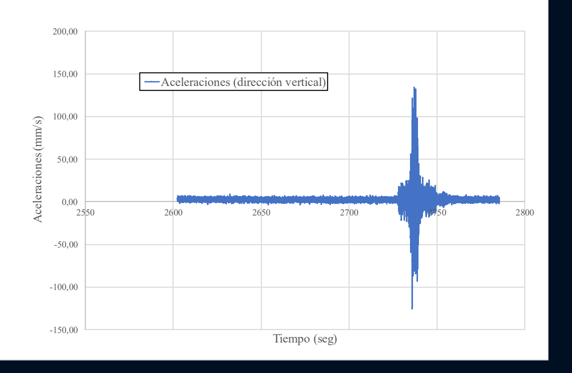






Load Tests

Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata



Load Tests

Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata

Frequency domain values		**Mode 1 (vertical)**	**Mode 2 (vertical)**	**Mode 4 (transversal)**	**Mode 5 (transversal)**
		3,9	**4,36**	**6,81**	**7,64**
Spam	Hipothesis	Registered peak values (Hz)			
		1	2	3	4
1	40 km/h	3,99	4,32	5,92	6,63
	Max	4,19	5,00	5,87	7,12
	Braking + Max	4,26	4,75	6,24	7,10
8	40 km/h	3,99	4,74	6,26	7,17
	Máxima	4,12	4,45	6,57	7,01
	Braking + Max	4,18	4,63	6,19	7,24

Frequency domain values		**Mode 1 (vertical)**	**Mode 2 (vertical)**	**Mode 4 (transversal)**	**Mode 5 (transversal)**
		3,9	**4,36**	**6,81**	**7,64**
Average	40 km/h	3,99	4,53	6,09	6,90
	Max	4,16	4,73	6,22	7,07
	Braking + Max	4,22	4,69	6,22	7,17

Measurement / Prediction	40 km/h	102,3%	103,9%	89,4%	90,3%
	Max	106,5%	108,4%	91,3%	92,5%
	Braking + Max	108,2%	107,6%	91,3%	93,8%

Load Tests

Extremadura, Spain. Ashvin demosite #1.
Viaducto de la Plata

Frequency domain values		Mode 1 (vertical)	Mode 2 (vertical)	Mode 4 (transversal)	Mode 5 (transversal)
		3,9	**4,36**	**6,81**	**7,64**
Spam	Hipothesis	Registered peak values (Hz)			
		1	2	3	4
1	40 km/h	3,99	4,32	5,92	6,63
	Max	4,19	5,00	5,87	7,12
	Braking + Max	4,26	4,75	6,24	7,10
8	40 km/h	3,99	4,74	6,26	7,17
	Máxima	4,12	4,45	6,57	7,01
	Braking + Max	4,18	4,63	6,19	7,24

Frequency domain values		Mode 1 (vertical)	Mode 2 (vertical)	Mode 4 (transversal)	Mode 5 (transversal)
		3,9	**4,36**	**6,81**	**7,64**
Average	40 km/h	3,99	4,53	6,09	6,90
	Max	4,16	4,73	6,22	7,07
	Braking + Max	4,22	4,69	6,22	7,17
Measurement / Prediction	40 km/h	102,3%	103,9%	89,4%	90,3%
	Max	106,5%	108,4%	91,3%	92,5%
	Braking + Max	108,2%	107,6%	91,3%	93,8%

Bits and pipelines

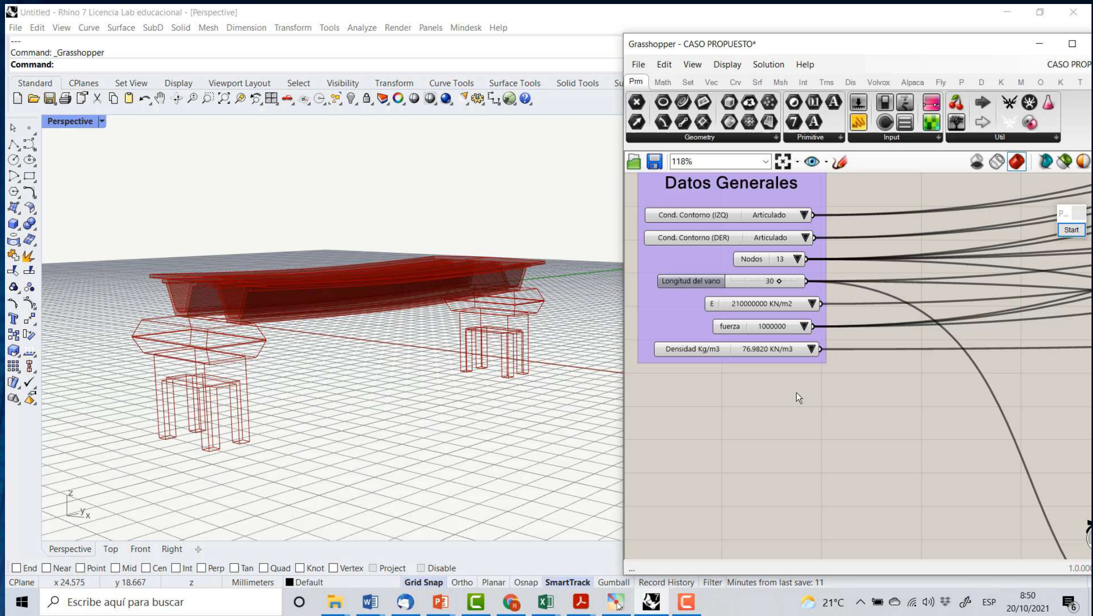
Extremadura, Spain.
Ashvin demosite #1.
Viaducto de Valdelinares

BIM

BrIM

IFC Semantically-rich models

Bits and pipelines



Models

Beams-Shells

BIM-compatible

Computational geometry tools

Elastic analysis

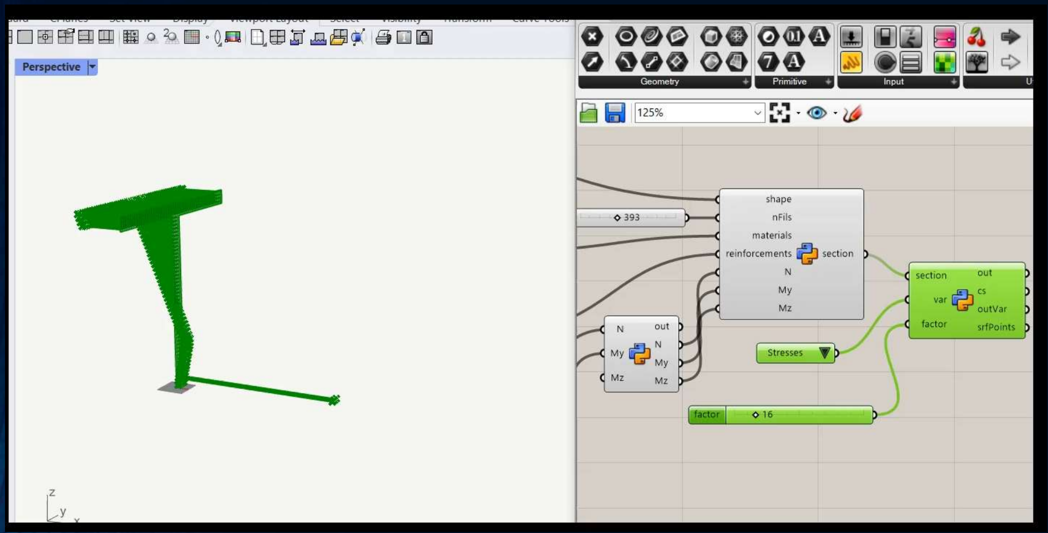
Modal analysis

Extremadura, Spain.

Ashvin demosite #1.

Viaducto de Valdelinares

Bits and pipelines



Models

Beams-Shells

BIM-compatible

Computational geometry tools

Inelastic analysis

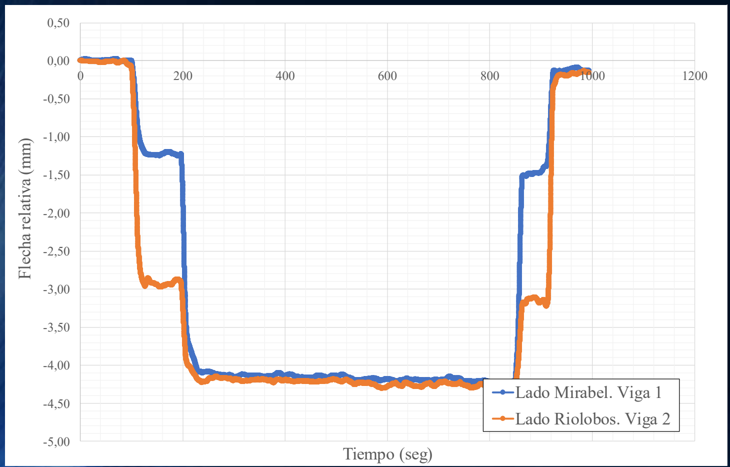
Bits and pipelines

Extremadura, Spain.
Ashvin demosite #1.
Viaducto de Valdelinares

Sensors

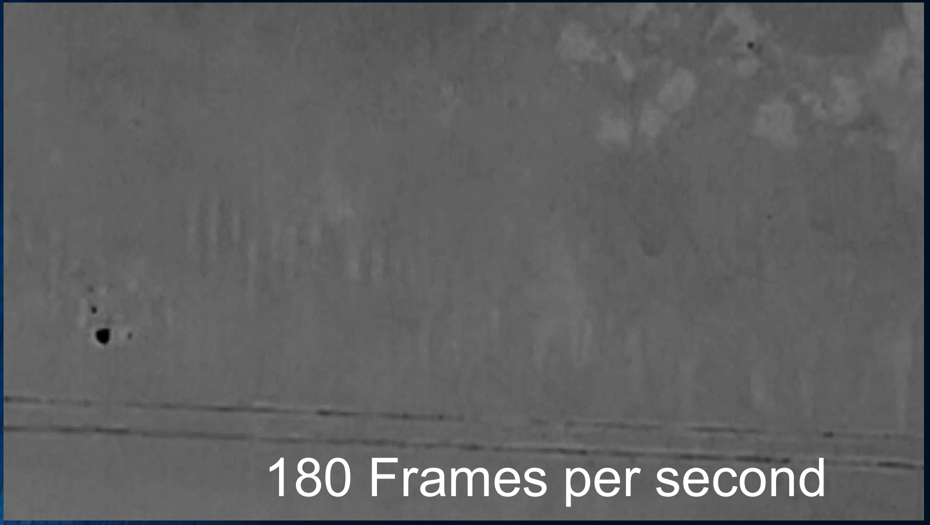
IoT

Robust data aggregation



Strain gauges
LVDT
Inclinometers
Weather Station

Bits and pipelines



Extremadura, Spain.
Ashvin demosite #1.
Viaducto de Valdelinares

Video
Image-based methods
Photogrammetry
Data under treatment

Bits and pipelines

Extremadura, Spain.
Ashvin demosite #1.
Viaducto de Valdelinares

Video

Image-based methods

Telemmetry

Bits and pipelines

Video
Image-based methods

Reportage

Extremadura, Spain.
Ashvin demosite #1.
Viaducto del Tajo

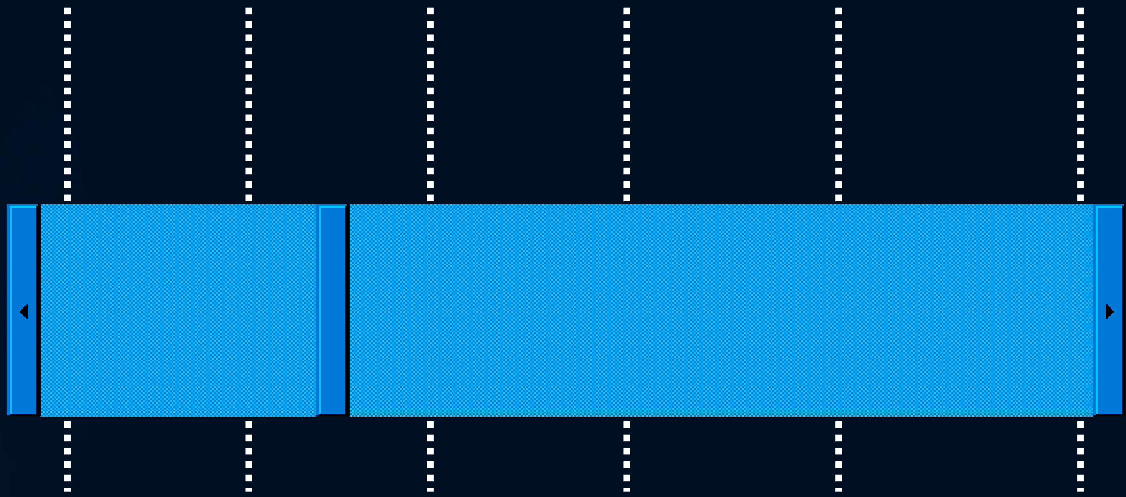
Bits and pipelines

Extremadura, Spain.
Ashvin demosite #1.
Viaducto de Almonte

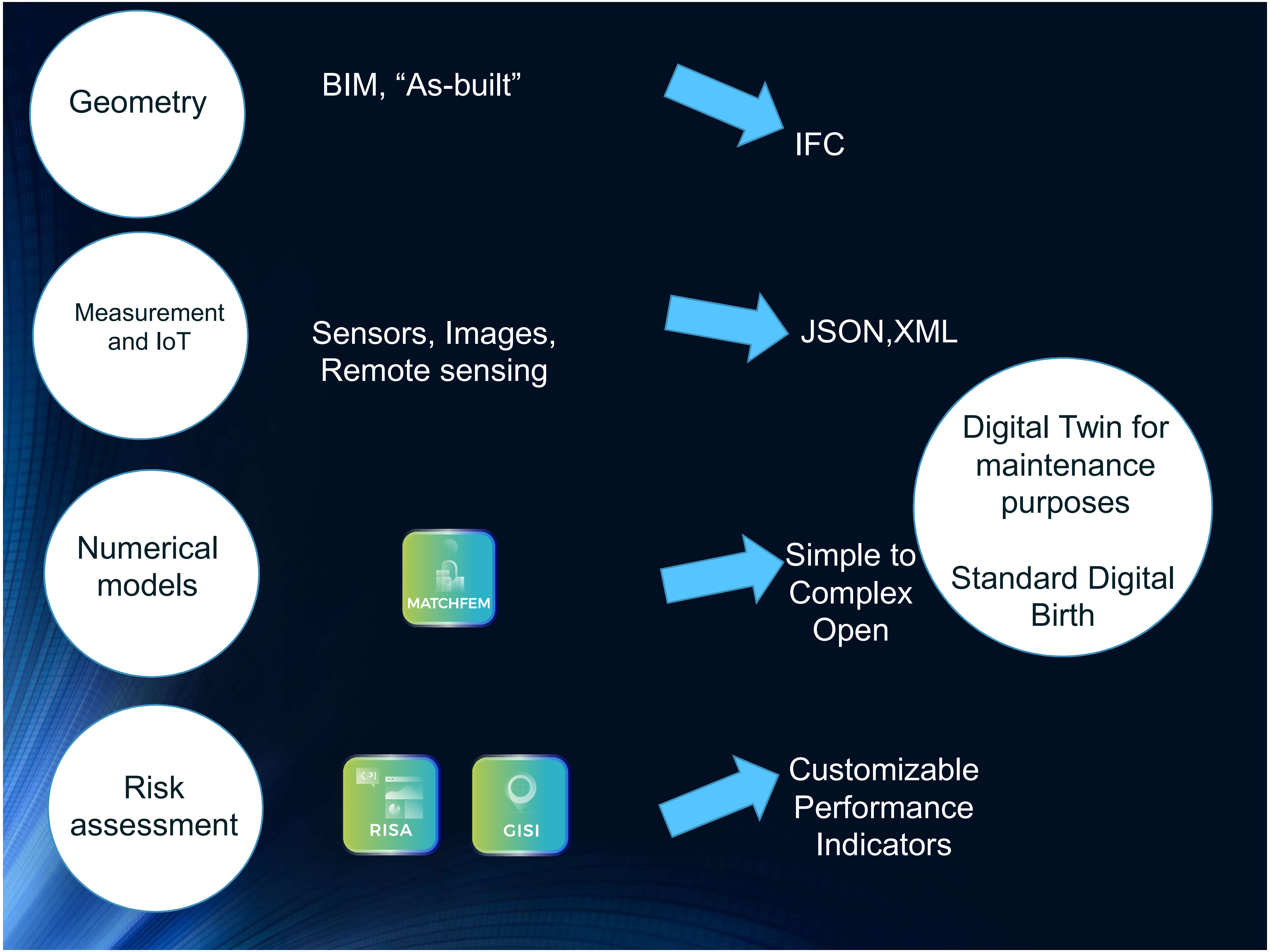
Point Cloud

Remote sensing techniques

TLS
InSAR
Data under treatment



Level of Digitalization Thresholds


Geometry
BIM, "As-built"
IFC
Measurement and IoT
Sensors, Images, Remote sensing
JSON,XML
Digital Twin for maintenance purposes
Standard Digital Birth
Numerical models
MATCHFEM
Simple to Complex Open
Risk assessment
RISA
GISI
Customizable Performance Indicators

Better understanding of the behavior

Reduced probability of failure

Economic benefit related to new digital needs

The load test as the ideal moment for digitally twinning the asset

Digitally twinned load tests in railway bridges.

Bits and pipelines to a Standard. The Ashvin contribution

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH — Conception, Measurement, MatchFEM, Assessment

MAINFLUX Internet of Things Solutions; infra plan konzalting — IoT, Risk Assessment

DIGITAL TWIN TECHNOLOGY — Dashboards

AUSTRIAN STANDARDS — Standard perspective

CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS — Image-based methods