Enabel

ARCHIE –M Software

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Venue: University of Dar Es Salaam UDSM

Belgian development agency

enabel.be

Content

- Introduction to software
- Input design parameters
- Input design geometry

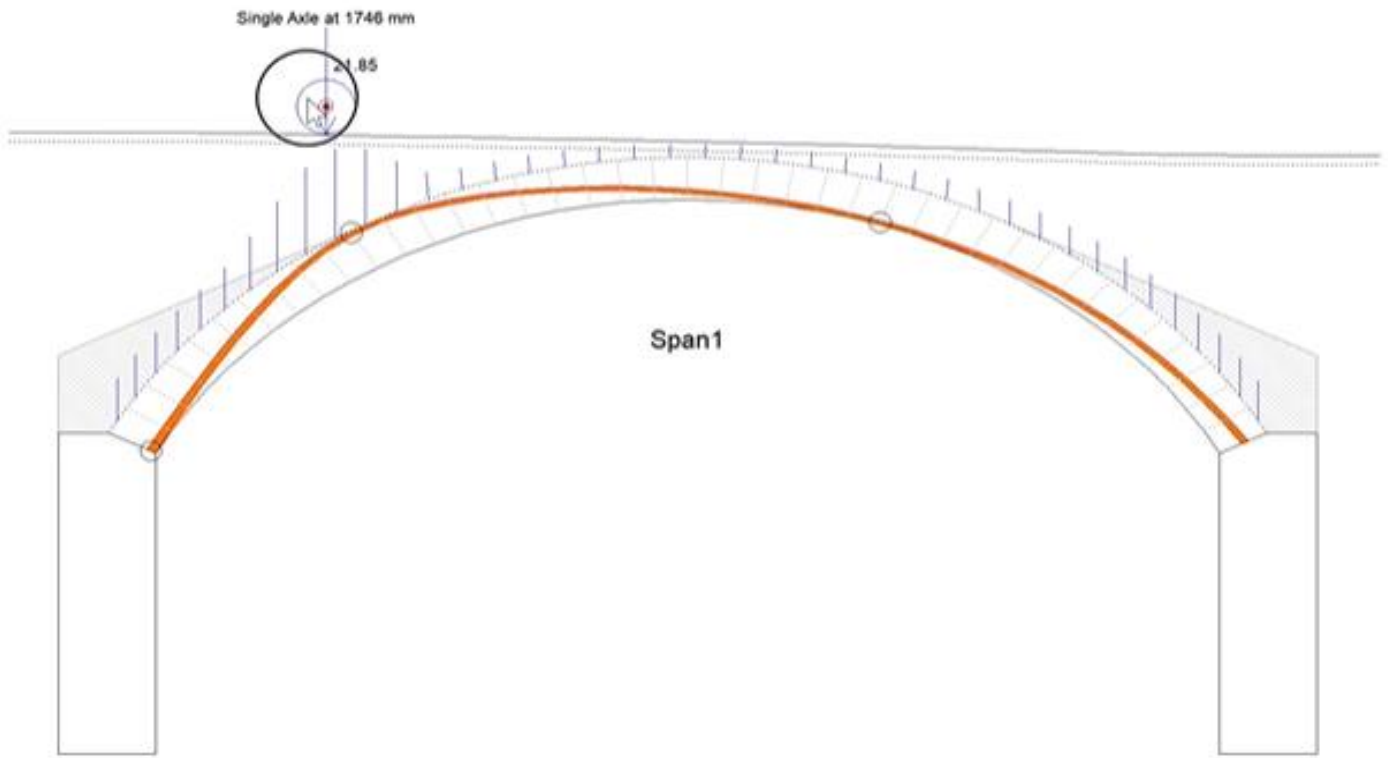
1.Introduction to Archie-M software

- Archie-M is a standard assessment tool for masonry bridges in the UK rail network.
- The needs for assessing masonry bridges came on world war I MEXE was used now we have archie.M

- Versions of Archie have been in use since 1985. Now it has 40years and it is used worldwide.

Thrust line

- Understand that for our stone arch bridge to be safe and stable a line of thrust must stay within arch material after applying all load effect. (Heyman in the 1950s)



Input design parameters based on DMRB CS454

- 10N/mm2 masonry compressive strength.
- unit weight of 20kN/m3 for masonry.
- 18kN/m3 for backing and surface fill.

- Figure 1 shows the indicative compressive strength for the tested bridge in Kigoma region.
- The Rebound Number (RN) is converted into indicative compressive strength using conversion tables. Although the conversion has been developed for concrete, it also gives reasonable estimates for masonry. For improved accuracy, the rebound numbers can be calibrated for stone masonry based on test results

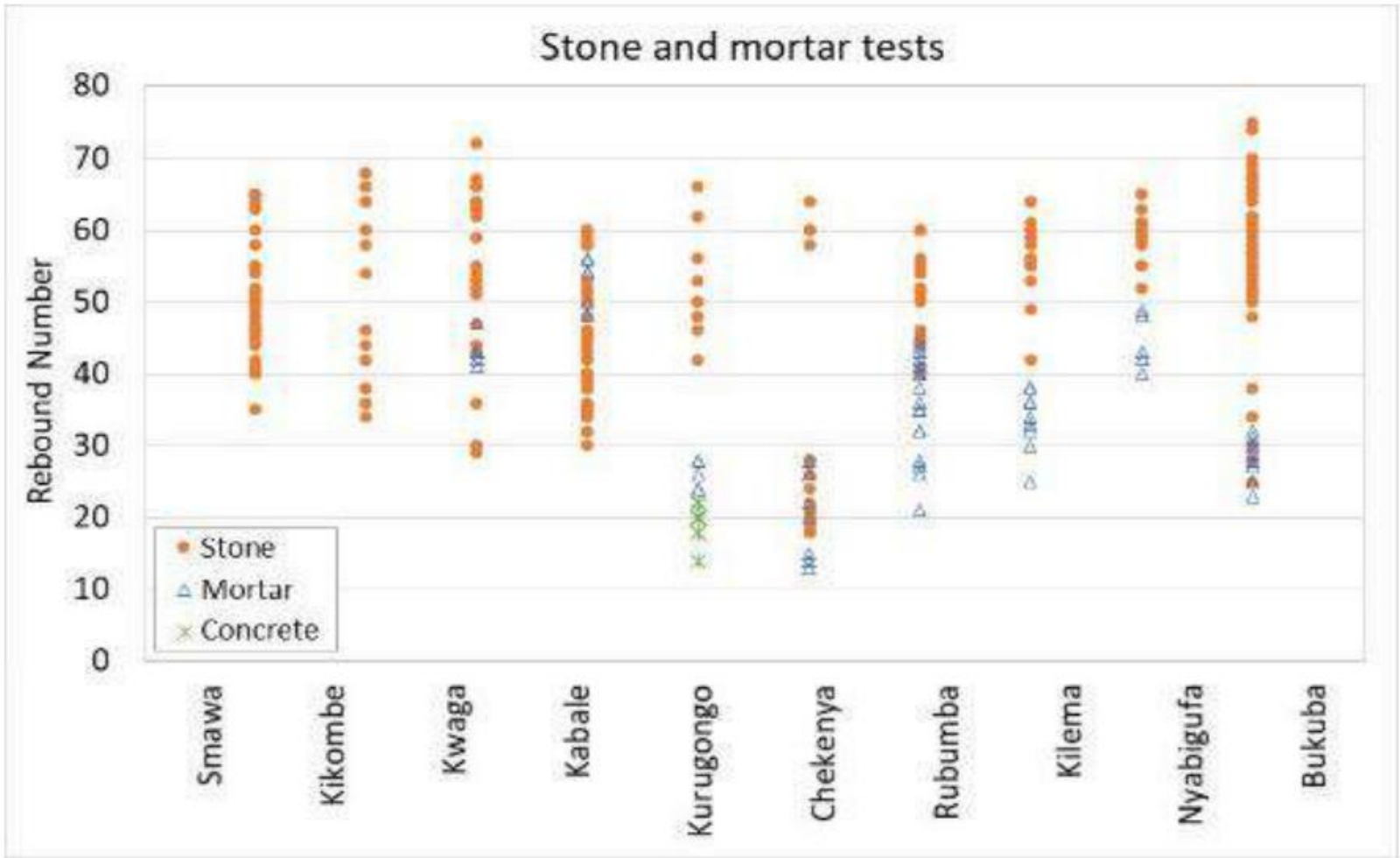
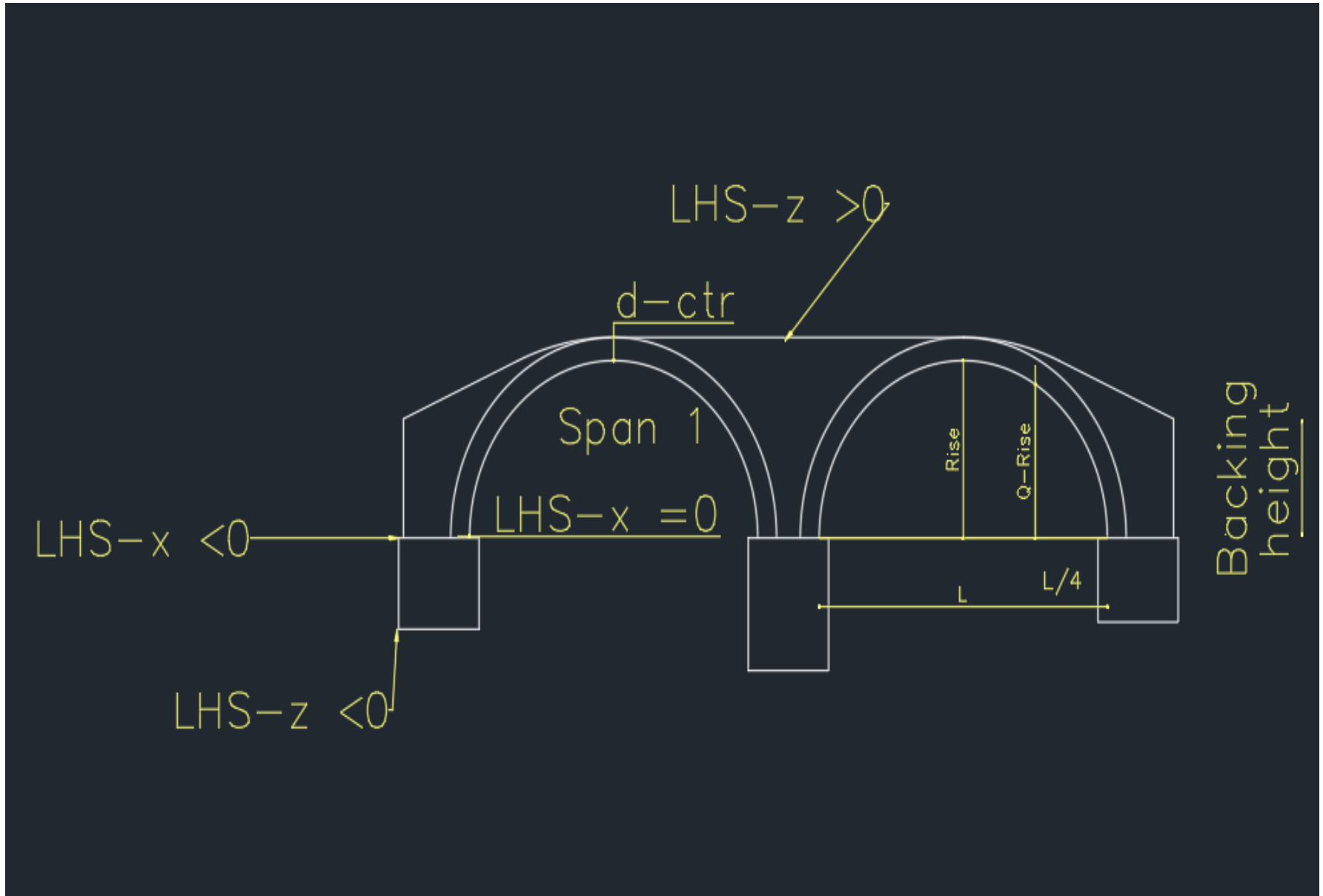
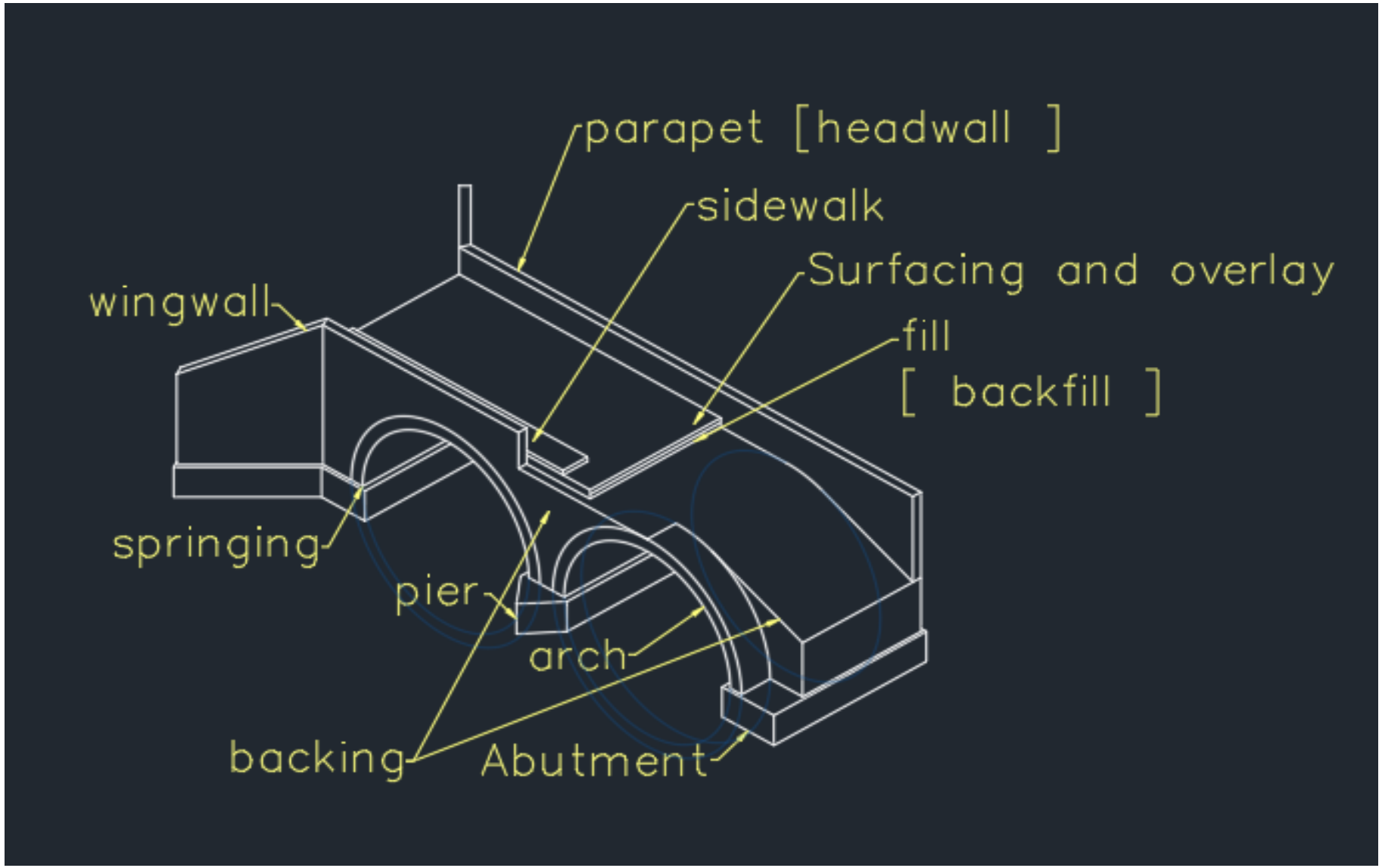


Figure 1 Relative mortar and stone strength for the tested bridges and indicative strength of softer mortars

Input design geometry

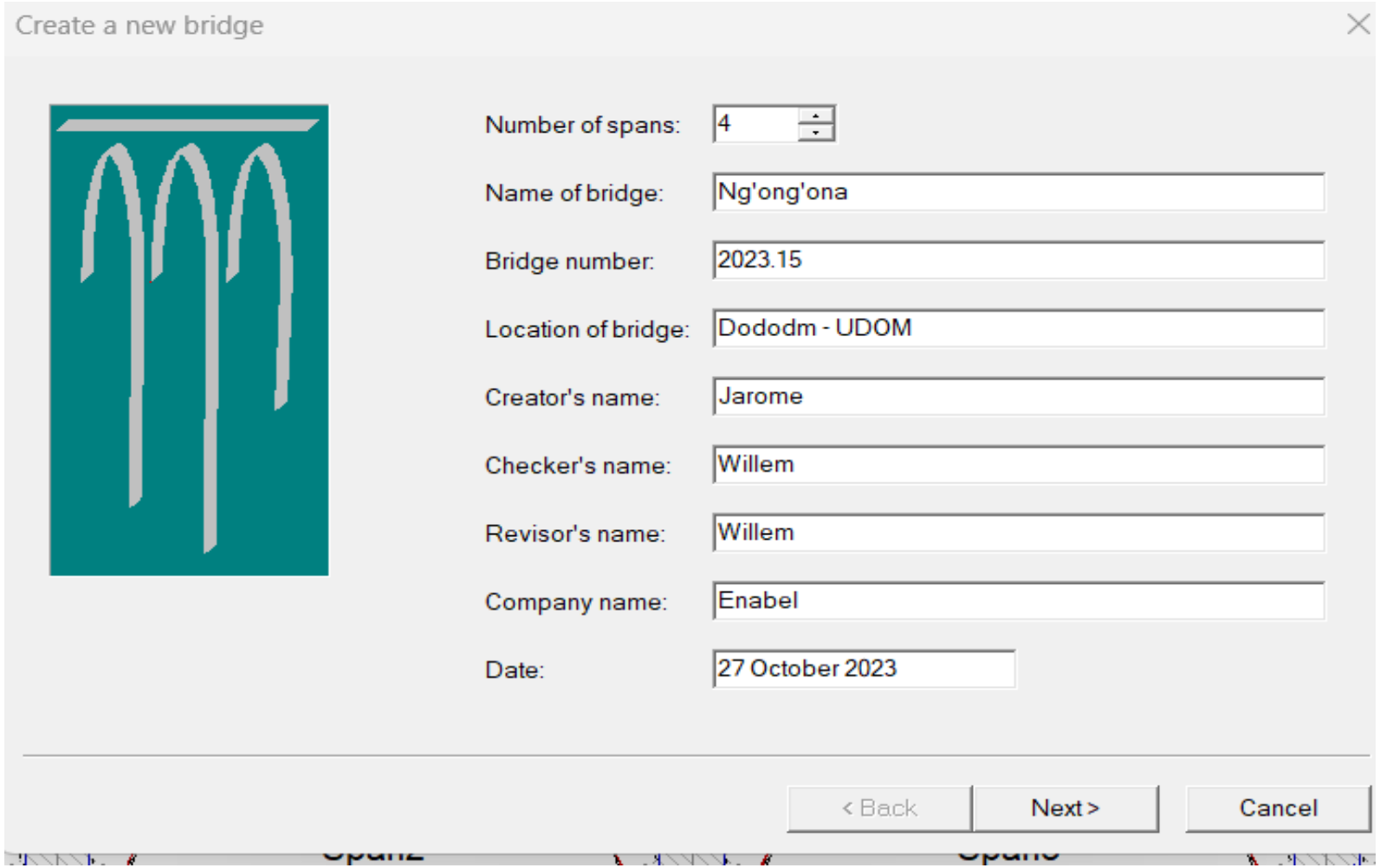


Terminologies

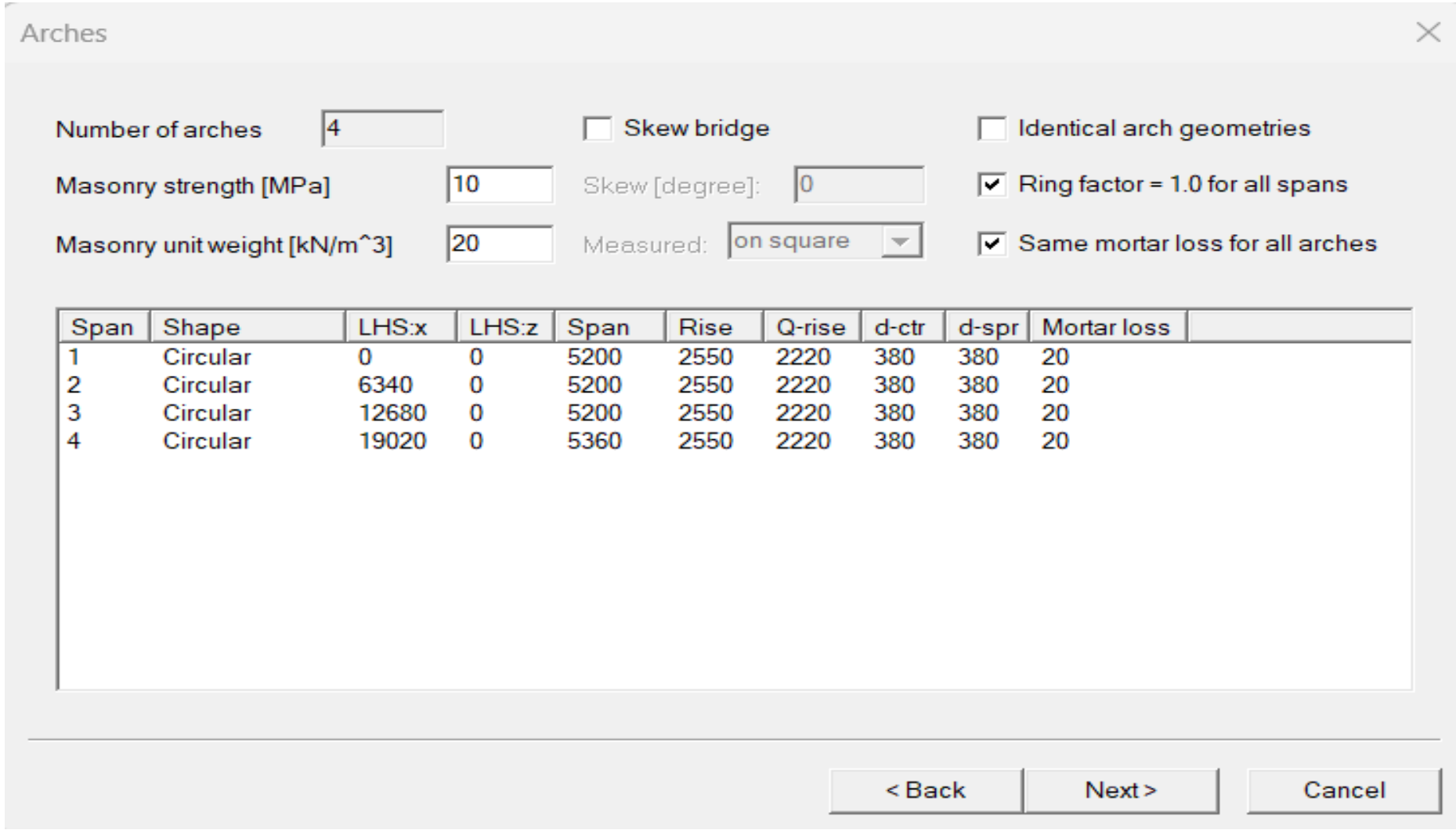


ARCHIE –M Software

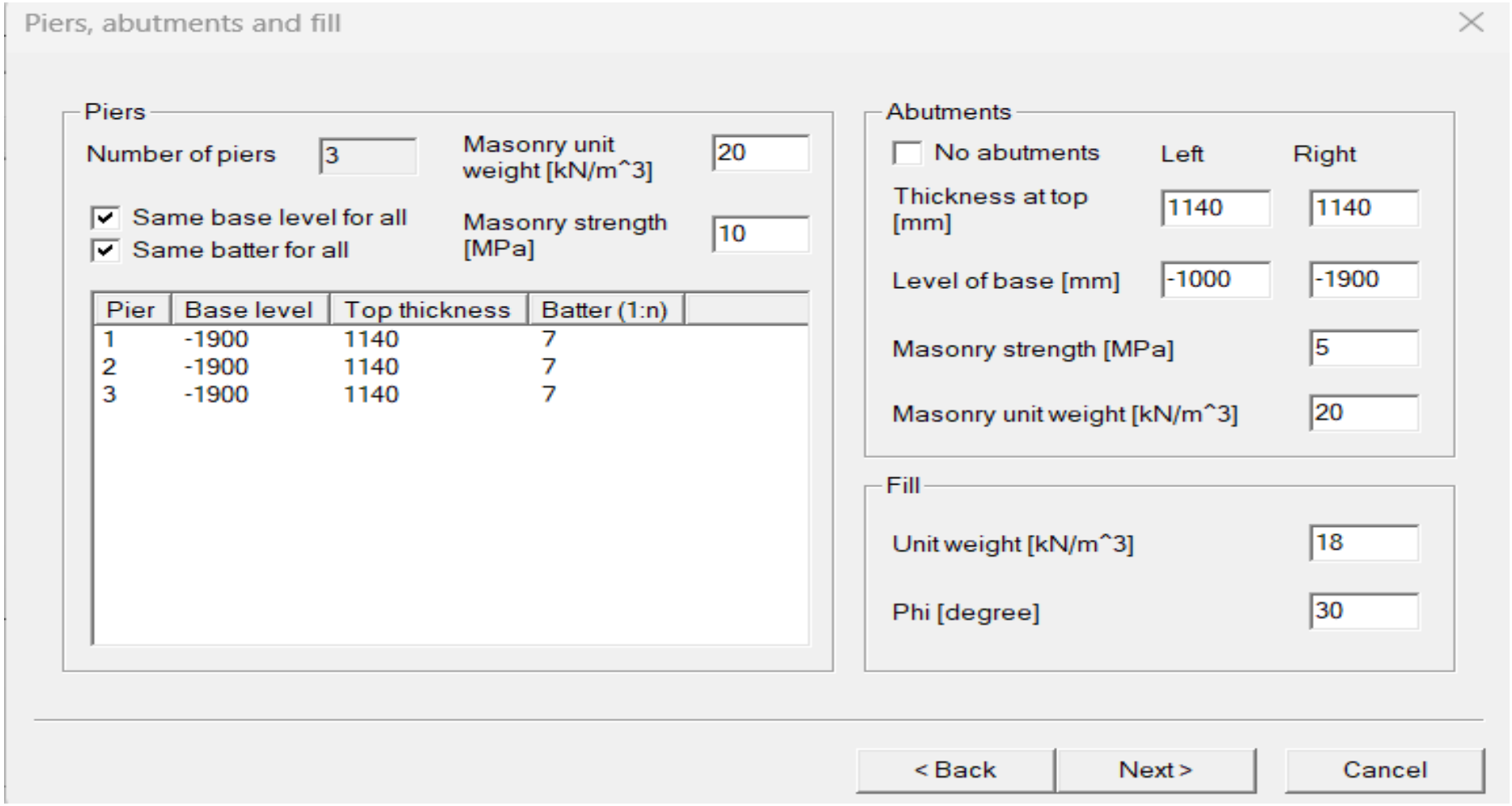
- 1. Create new bridge



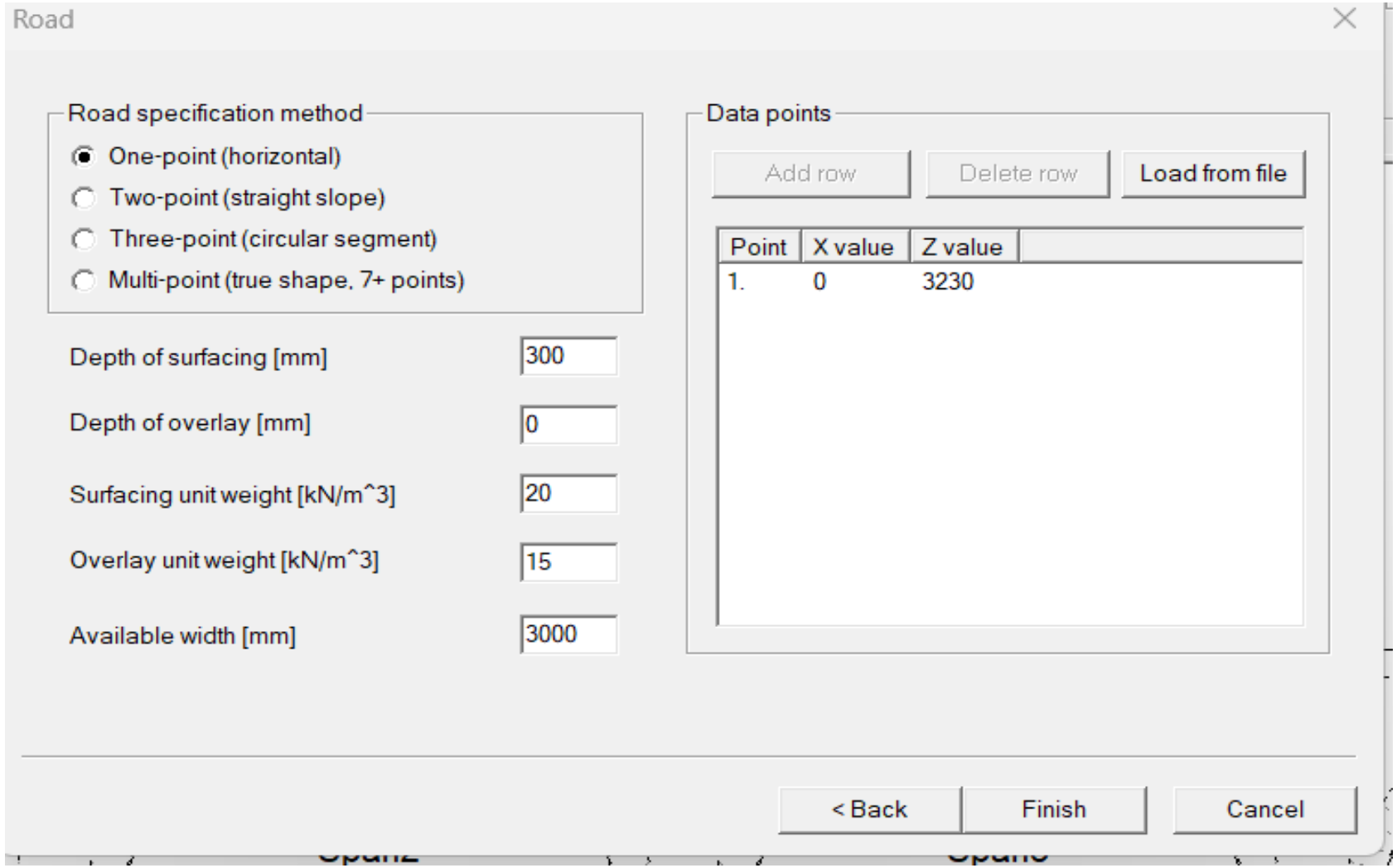
Fill in your arch details



Pier, Abutments and Fill



Road alignments



Partial factors in standards and guidance CS454, C800

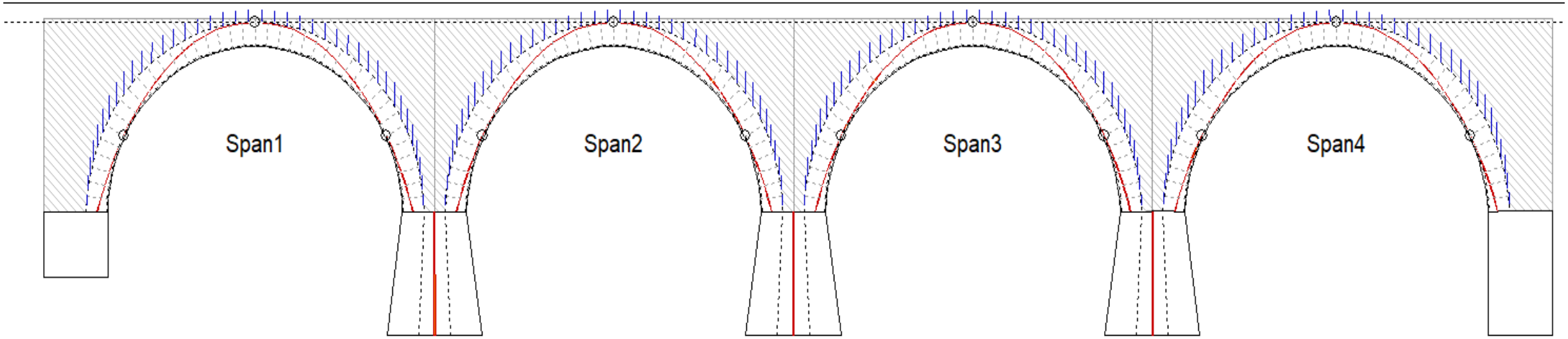
- Factor for live load (ɣ*fL)* (SLS|ULS)

Generally > 1.0 if and only if this gives a worse result than taking the value

e as 1.0.

- ɣf3 is a factor that takes account of inaccurate assessment of the effects of actions such as unforeseen stress distribution in the structure.
- For other Factors please click here

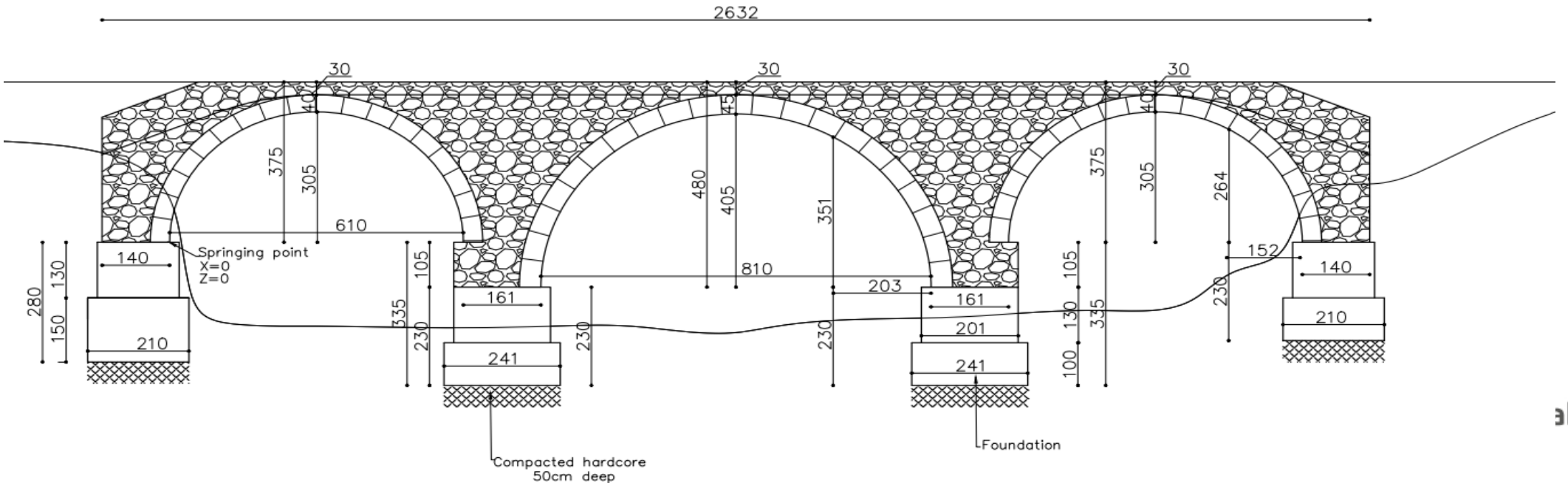
Your bridge will be displayed



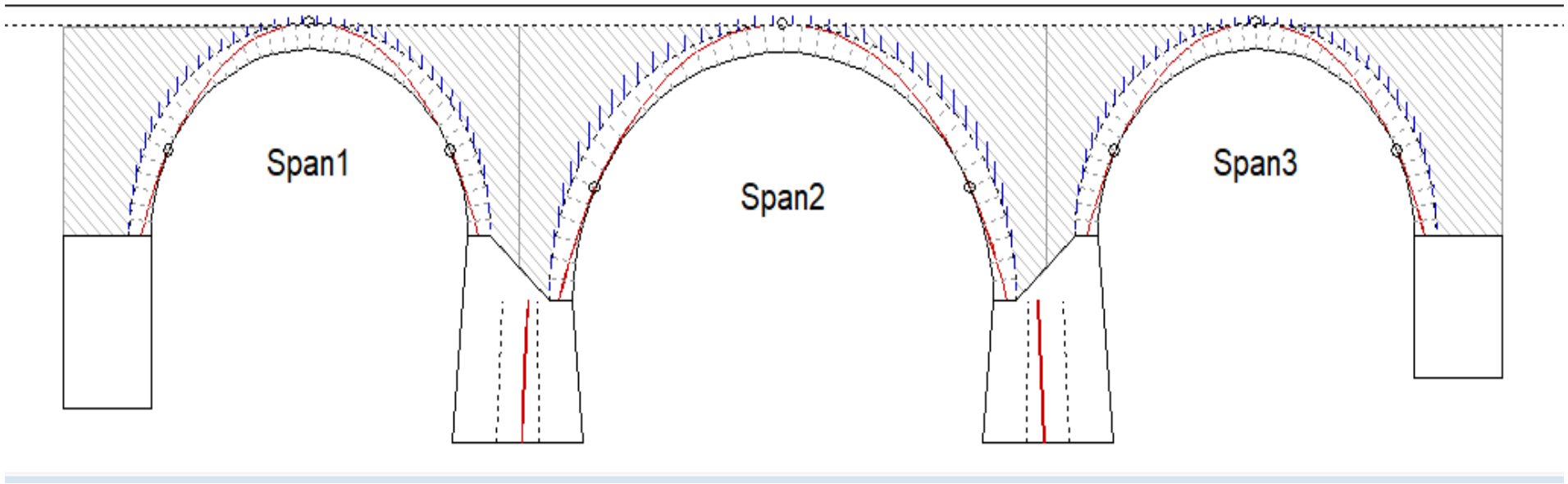
Quiz

Quiz no 1.

1. Draw/Model a given section X–X' below of stone arch bridge in Archie M.
Bridge name; Mkeha, Location; Njombe Wanging'ombe District
   i. Full backing height
   ii. Mortar loss 20mm
   iii. Not same arch factor
   iv. Masonry strength 10Mpa
   v. Masonry Unit weight 20KN/m3
   vi.

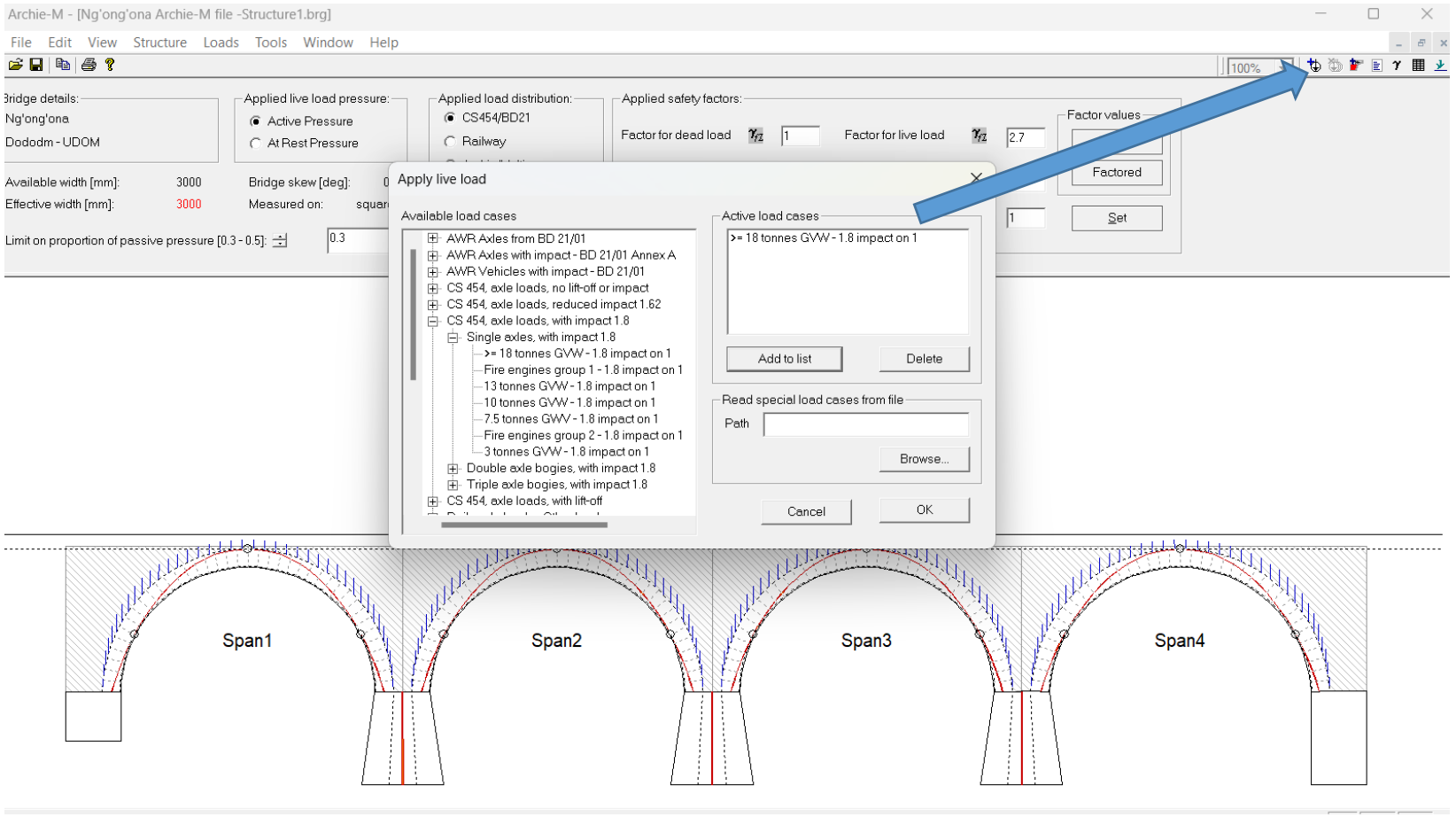


Quiz results



Break for breack fast

Assess the bridge capacity by applying live loads



Checking thrust line for multspan arch bridges taking into account applied backing

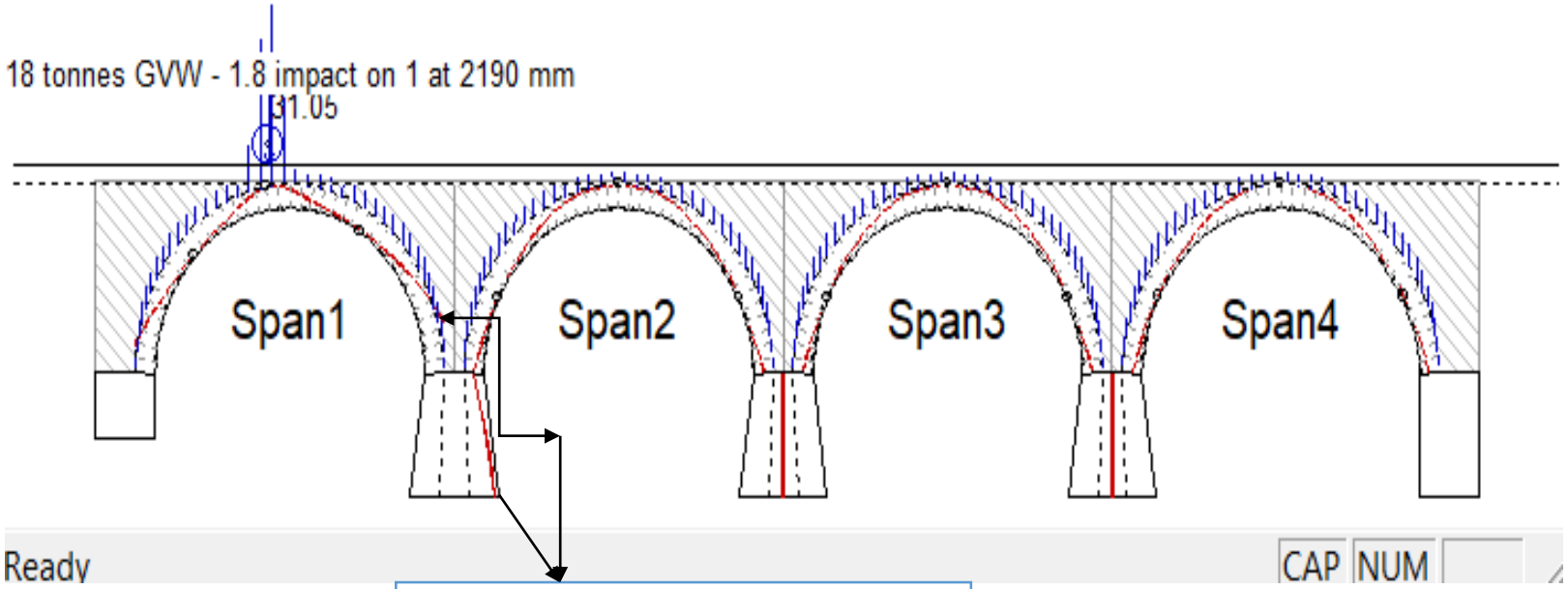
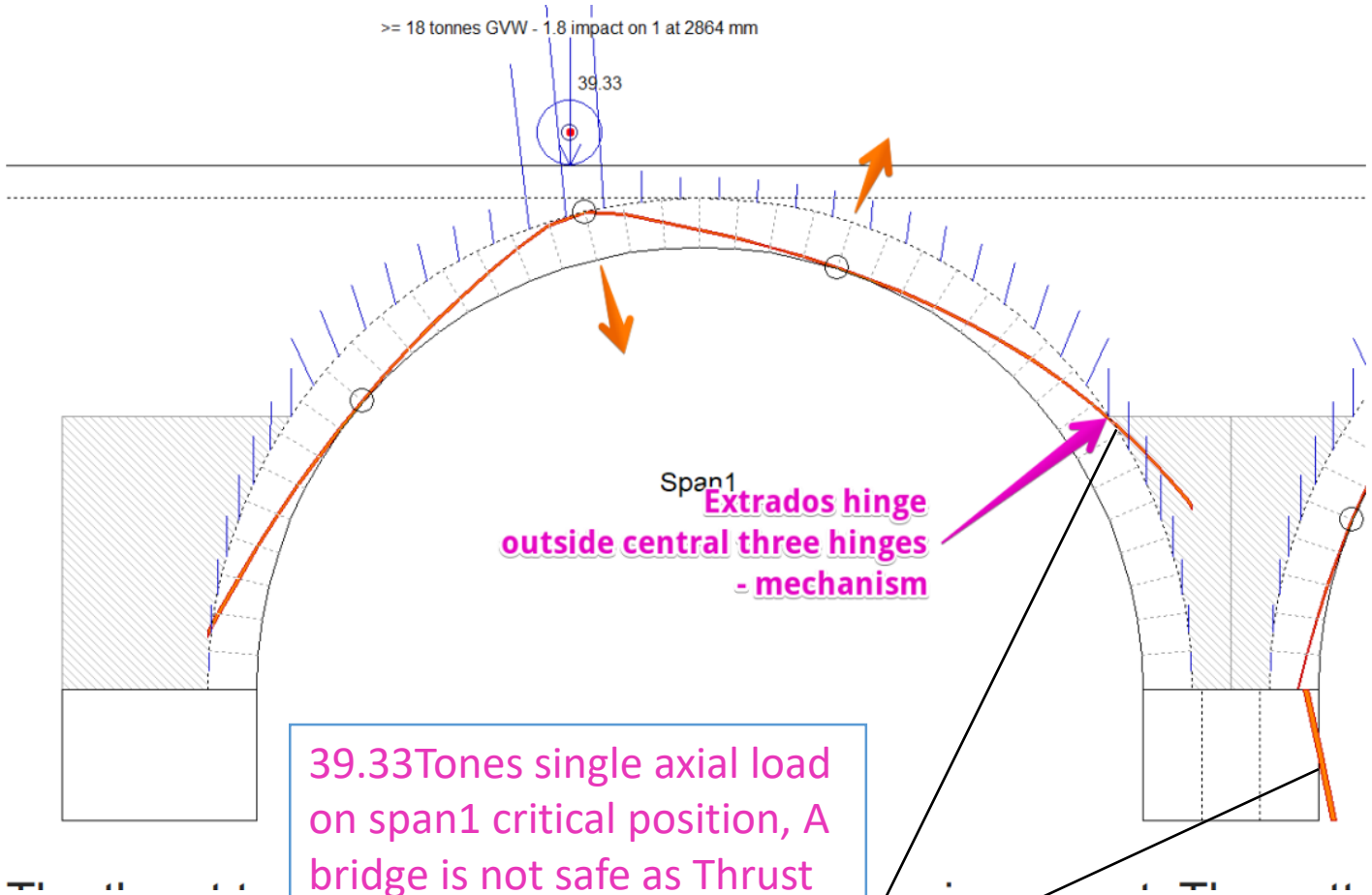


Figure 1:
Full backing

31.05Tones single axial load on span1 critical position, no failure as Thrust line within pier and not out of masonry.

Checking thrust line for multspan arch bridges taking into account applied backing



39.33Tones single axial load on span1 critical position, A bridge is not safe as Thrust line out of pier and out of backing masonry.

Figure 2: Half backing height

Checking thrust line for multspan arch bridges taking into account applied backing

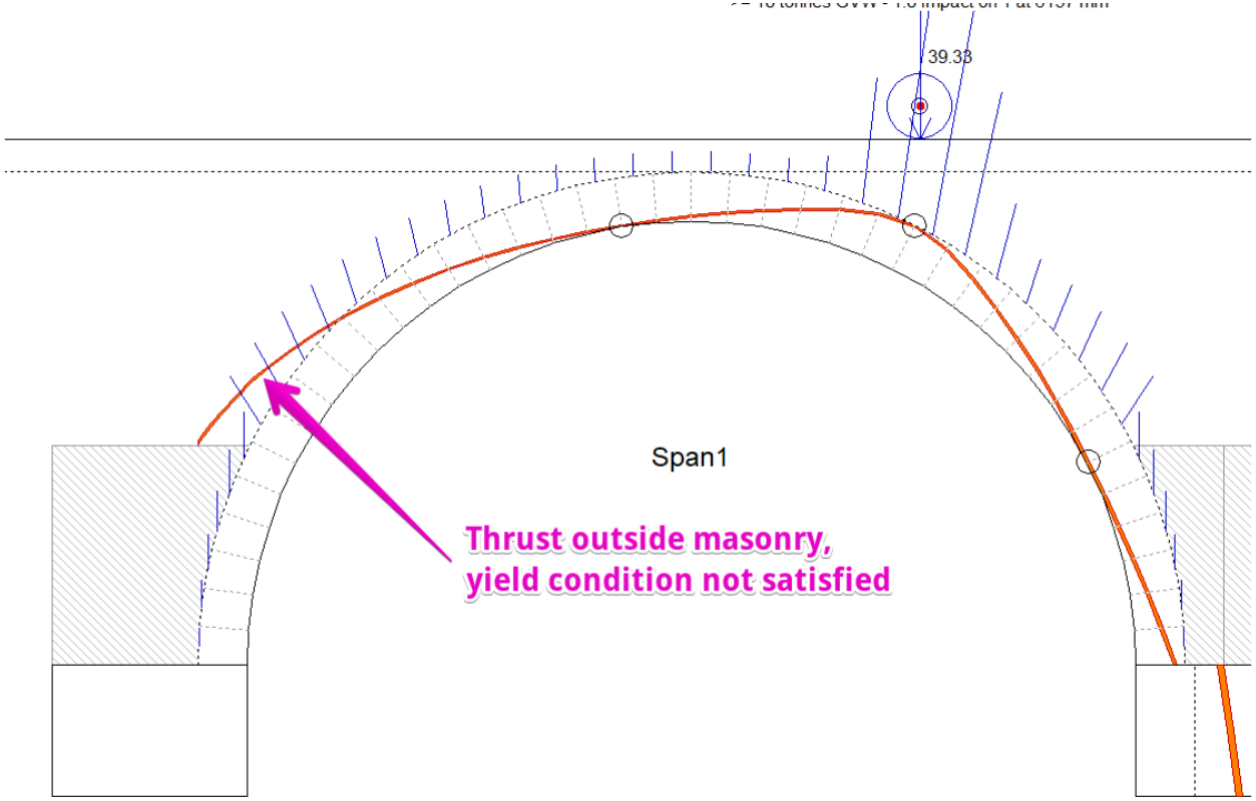


Figure 3: Almost half backing height

Comments

- Figure 1: With full height masonry, there is no possibility of a hinge forming at the extrados, because the masonry behind that point cannot compress or move out of the way. The only form of yield that could occur here is shear between the ring and the backing masonry. In a structure like this, there is really no possibility of a 4 bar mechanism forming.

- Figure 2 and 3: The thrust touches the extrados, so a hinge is present. The pattern of 4 hinges alternating between intrados and extrados forms a mechanism, so this structure might collapse, and would at least deform unacceptably (passive pressure from the full could stop full collapse; also bear in mind that we are applying a live load factor).

The corresponding results for figure 1 look like this:

live	Fx passive	Fx total	Fz total	My total	Thrust in	Thrust out	Extra-Thrust	
00	0.00	-58.70	-172.07	-298.89	1728	1746	-1296	***
00	0.00	-73.50	-167.89	-279.03	1603	1620	-1170	***
00	0.00	-87.09	-161.65	-258.39	1482	1500	-1050	***
00	0.00	-99.43	-153.72	-237.29	1365	1383	-933	***
00	0.00	-110.49	-144.47	-215.99	1251	1268	-818	***
00	0.00	-120.27	-134.24	-194.70	1137	1154	-704	***
00	0.00	-128.79	-123.36	-173.62	1023	1040	-590	***
00	0.00	-136.10	-112.15	-152.93	909	926	-476	***
00	0.00	-142.28	-100.88	-132.79	795	812	-362	***
00	0.00	-147.39	-89.79	-113.38	683	700	-250	***
00	0.00	-151.55	-79.08	-94.89	574	590	-140	***
00	0.00	-154.86	-68.91	-77.51	469	485	-35	***
00	0.00	[illegible]	[illegible]	-61.42	[illegible]	[illegible]	63	
00	0.00	-159.36	-50.58	-46.84	280	297	153	
00	[illegible]	[illegible]	[illegible]	-33.96	201	217	233	
00	0.00	-161.77	-35.16	-22.98	133	149	301	
00	0.00	-162.45	-28.48	-14.09	78	94	356	
00	0.00	-162.88	-22.36	-7.43	37	54	396	
00	0.00	-163.15	-16.70	-3.15	11	27	423	
00	0.00	-163.28	-11.36	-1.33	-0	16	434	
00	0.00	-163.33	-6.18	-2.03	4	21	429	
00	0.00	-163.28	-1.00	[illegible]	24	40	410	
00	[illegible]	[illegible]	[illegible]	-10.98	60	76	374	
00	0.00	-162.88	10.00	-19.12	111	127	323	
00	0.00	-162.45	16.12	-29.55	177	193	257	
33	0.00	-161.66	23.69	-42.19	258	274	176	
76	0.00	-159.33	39.68	-56.54	345	361	89	
61	0.00	-154.03	68.58	-70.21	412	428	22	
78	0.00	-145.40	107.45	-79.74	432	450	-0	***
.79	0.00	-134.41	149.05	-82.58	405	[illegible]	25	
48	0.00	-122.71	186.46	-78.15	347	368	82	
75	0.00	-111.78	215.96	-67.83	275	298	152	
33	0.00	[illegible]	[illegible]	[illegible]	202	228	222	
61	0.00	-93.95	252.99	-39.92	138	164	286	
40	0.00	-86.00	265.27	-27.09	85	112	338	
02	0.00	-77.44	276.21	-16.92	45	74	376	
00	0.00	-67.66	286.44	-9.80	19	48	402	
00	[illegible]	[illegible]	[illegible]	-5.74	4	34	416	
00	0.00	-44.26	303.62	[illegible]	-0	31	419	
00	0.00	-30.67	309.86	-6.48	5	36	414	
00	0.00	-15.87	314.04	-10.96	19	51	399	

Additional extrados hinge

Intrados hinge

Extrados hinge

Intrados hinge

Finding worst

Load case

>= 18 tonnes

Checking series of *** in the results table

- The lower single *** marks the central extrados hinge, and should always be present. The upper set of *** at the last column indicate flag lines where the thrust has touched or gone outside the extrados again.

- With no backing, three *** at more than one low this indicates failure. With backing, Archie-M does not attempt to interpret this situation. It marks rows where the thrust exits the arch ring still, but does not flag this as FAIL in auto-run. Instead it shows the "offset proportion" - the ratio of the position of the thrust to the ring thickness, so 1.0 is contact with the extrados ***see figure 4 bellow.***

Checking series of *** in the results table

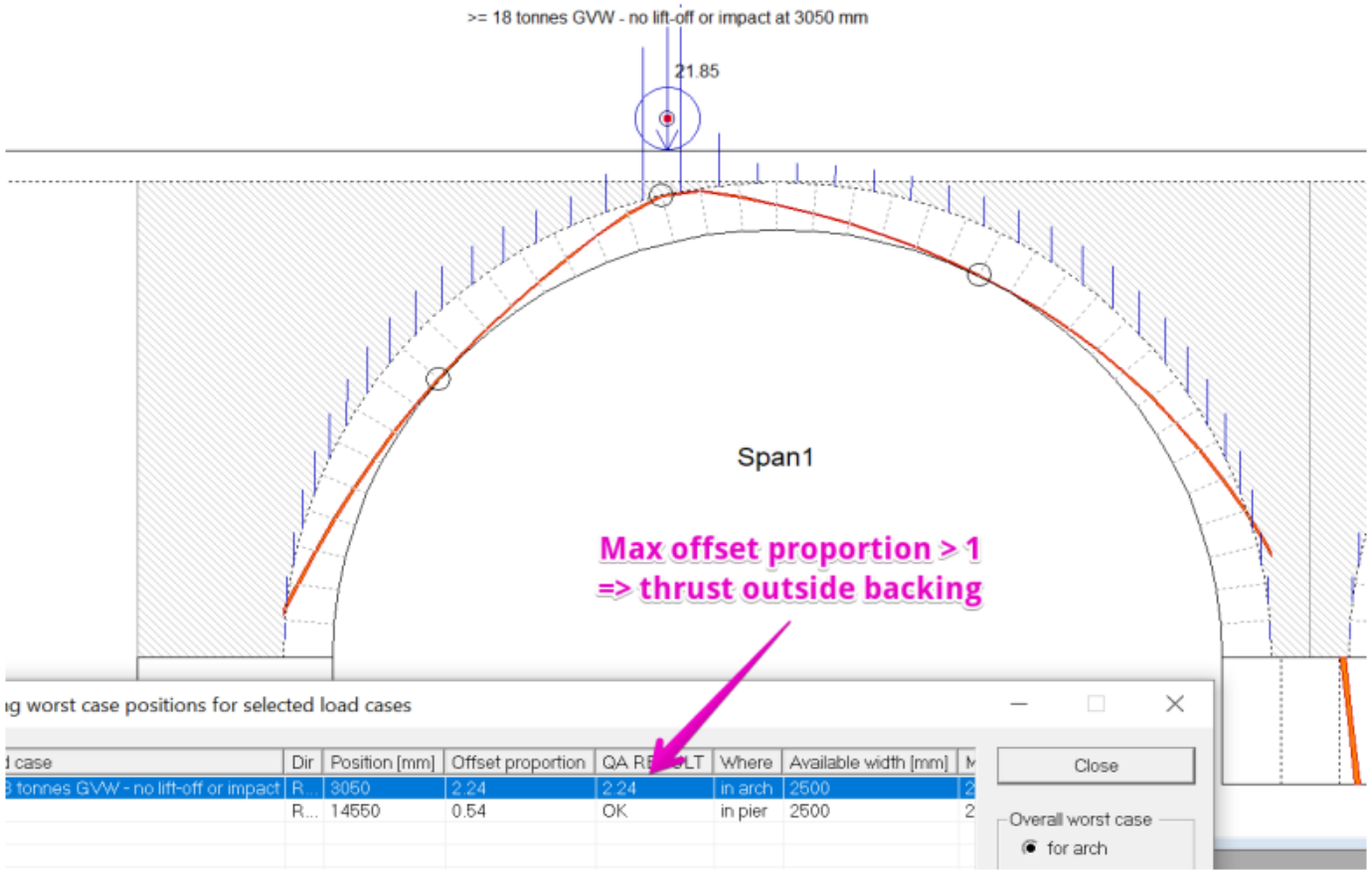
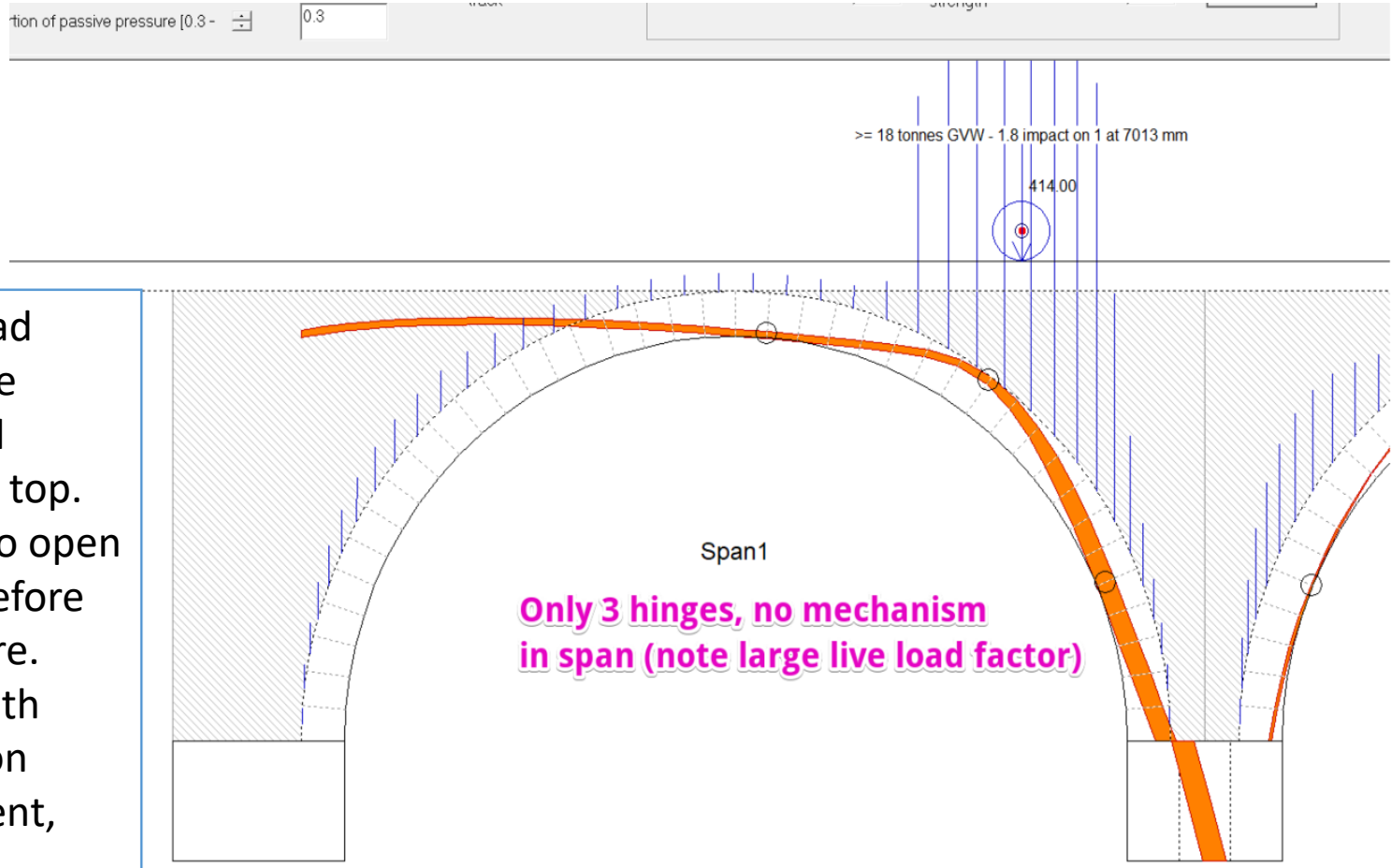


Figure 4:

Checking thrust line



With large live load factor a thrust line become thick and almost straight at top. This could crack to open at the deck. Therefore this indicate failure. Note: a bridge With backing depend on Engineers judgment, and by the way 414Tones of live load is not realistic.

EAC road loading LAW 2016

Max allowable single axle load is 10Tones

East African Community Vehicle Load Control Act, 2016

SECOND SCHEDULE

s.4(1)

AXLE LOAD LIMITS

Permissible Maximum Axle Load Limits

Axle Type	*Number of tyres on the axle*	*Type of tyre*	*Permissible limit (metric tonnes)*
Single	2	Conventional	8
Single	4	Conventional	10
Tandem	8	Conventional	18
	4	Super single	16
Tridem	12	Conventional	24
	6	Super single	22.5
Liftable single	4	Conventional	10
Liftable single	2	Super single	8.5

Permitted GVM by TANROADS

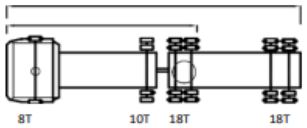
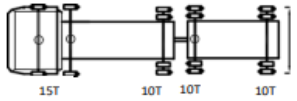
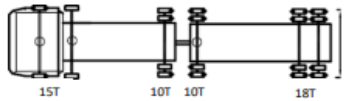
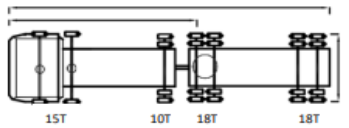
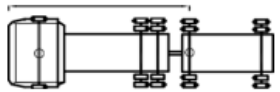
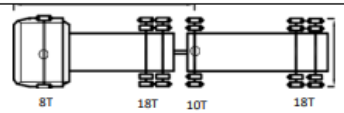
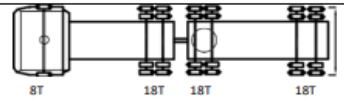
MINISTRY OF WORKS, TRANSPORT AND COMMUNICATION

TANZANIA NATIONAL ROADS AGENCY (TANROADS)

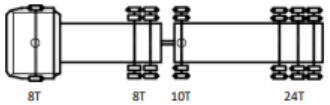
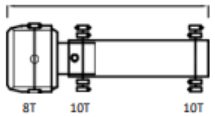
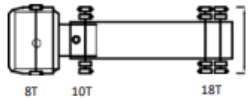
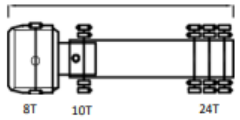
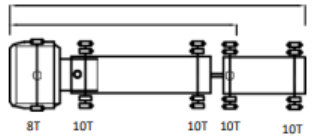
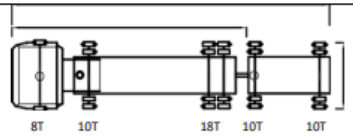
WEIGHBRIDGE OPERATIONAL MANUAL

December, 2018

Permitted GVM by TANROADS

S/N	ILLUSTRATION	TYPE OF VEHICLE	CONFIGURATION	PERMITTED GVM (TONS)
7		RIGID TRUCK & TRAILER	ALP SS,S4,DR8,D8 NUM - 1.2+22.22	54
8		RIGID TRUCK & TRAILER	ALP SD,S4,DR4,S4 NUM -11.2+2.2	45
9		RIGID TRUCK & TRAILER	ALP SD,S4,DR4,D8 NUM -11.2+2.22	53
10		RIGID TRUCK & TRAILER	ALP SD,S4,DR8,D8 NUM -11.2+22.22	56
11		RIGID TRUCK & TRAILER	ALP SS,D8,DR4,S4 NUM -1.22+2.2	46
12		RIGID TRUCK & TRAILER	ALP SS,D8,DR4,D8 NUM -1.22+2.22	54
13		RIGID TRUCK & TRAILER	ALP SS,D8,DR8,D8 NUM -1.22+22.22	56

Permitted GVM by TANROADS

S/N	ILLUSTRATION	TYPE OF VEHICLE	CONFIGURATION	PERMITTED GVM (TONS)
14		RIGID TRUCK & TRAILER	ALP SS,D8,DR4,T12 NUM -1.22+2.222	56
15		TRACTOR &SEMI TRAILER (ARTICULATED)	ALP SS,S4,S4 NUM -1.2-2	28
16		TRACTOR &SEMI TRAILER (ARTICULATED)	ALP SS,S4,D8 NUM 1.2-22	36
17		TRACTOR &SEMI TRAILER (ARTICULATED)	ALP SS,S4,T12 NUM 1.2-222	42
18		TRACTOR &SEMI TRAILER (ARTICULATED)	ALP SS,S4,S4,DR4,S4 NUM 1.2-2+2.2	48
19		TRACTOR &SEMI TRAILER (ARTICULATED)	ALP SS,S4,D8,DR4,S4 NUM 1.2-22+2.2	56

Results table

Archie-M - [Kisasa bridge.brg:2]

File Edit View Window Help

Bridge Name:	Kisasa bridge			Bridge Location:	Kisasa Ddoma													
Bridge Number:	2023.13																	
Number of spans:	2																	
SAFETY FACTORS																		
Factor for deadload:	1.00	Factor for superimposed deadload:	1.00	Factor for surfacing:	1.00													
Factor for live load:	1.90	Factor for load effect:	1.00	Factor for material strength:	1.00													
Applied distribution mode:	Archie-M, BD21/97																	
Applied live load pressure:	Active pressure																	
STRUCTURE PROPERTIES																		
Road shape:	Flat line (1-point method)																	
Road points:	(0, 1940)																	
Depth of surfacing:	300	[mm]	Depth of overlay:	0	[mm]													
Surface unit weight:	20.00	[kN/m3]	Overlay unit weight:	1.00	[kN/m3]													
Available width:	3000	[mm]																
Min. effective width:	3000	[mm]																
Fill unit weight:	18.00	[kN/m3]	Fill phi:	30	degree													
Left abutment	Base level: -1500	[mm]	Height:	0	[mm]	Width:	1500	[mm]										
Right abutment	Base level: -1500	[mm]	Height:	0	[mm]	Width:	1500	[mm]										
SPAN 1																		
Shape:	Circular																	
Span:	6000	[mm]	Rise:	1200	[mm]	Q-rise:	0	[mm]										
Ring thickness at crown:	440	[mm]	Ring thickness at springing:			440	[mm]	Mortar loss: 0	[mm]									
Masonry unit weight:	20.00	[kN/m3]	Masonry strength:	5.00	[MPa]													
Backing:																		
Span	Position	Type	Height [mm]		Width [mm]	Unit weight [kN/m3]		Strength [MPa]										
1	left	Tangential	1340	0	20.00	5.00												
1	right	Tangential	1340	0	20.00	5.00												

Segment	Intrados.x	Intrados.z	Extrados.x	Extrados.z	Road.z	Fx dead	Fz dead	My dead	Fx live	Fz live	My live	Fx passive	Fx total	Fz total	My total	Thrust in	Thrust out	Extra-Thrust	
0	0	0	-303	319	1940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-131.70	-172.20	-4.57	-0	43	397	
1	122	112	-169	442	1940	0.00	-5.63	-1.11	0.00	-0.00	0.00	0.00	-131.70	-166.57	-9.05	22	64	376	
2	248	219	-30	560	1940	0.00	-5.44	-1.00	0.00	-0.00	0.00	0.00	-131.70	-161.13	-14.28	50	90	350	
3	378	321	113	672	1940	0.00	-5.24	-0.88	0.00	-0.00	0.00	0.00	-131.70	-155.89	-20.22	82	121	319	
4	512	418	261	779	1940	0.00	-5.03	-0.77	0.00	-0.00	0.00	0.00	-131.70	-150.86	-26.85	119	158	282	
5	650	510	412	881	1940	0.00	-4.81	-0.67	0.00	-0.00	0.00	0.00	-131.70	-146.04	-34.15	161	199	241	
6	791	597	567	976	1940	0.00	-4.59	-0.57	0.00	-0.04	-0.00	0.00	-131.70	-141.41	-42.09	209	246	194	
7	935	679	726	1066	1940	0.00	-4.37	-0.47	0.00	-1.94	-0.23	0.00	-131.70	-135.10	-50.16	261	297	143	
8	1082	754	888	1149	1940	0.00	-4.16	-0.38	0.00	-7.86	-0.91	0.00	-131.70	-123.08	-57.00	313	348	92	
9	1232	824	1053	1227	1940	0.00	-3.95	-0.30	0.00	-15.93	-1.67	0.00	-131.70	-103.20	-61.26	361	394	46	
10	1384	889	1221	1297	1940	0.00	-3.75	-0.23	0.00	-22.79	-2.10	0.00	-131.70	-76.66	-62.15	397	427	13	
11	1539	947	1392	1362	1940	0.00	-3.56	-0.16	0.00	-25.24	-1.98	0.00	-131.70	-47.87	-59.70	412	440	-0	***
12	1696	1000	1564	1420	1940	0.00	-3.38	-0.10	0.00	-21.87	-1.43	0.00	-131.70	-22.62	-54.78	400	427	13	
13	1855	1047	1739	1471	1940	0.00	-3.22	-0.05	0.00	-14.04	-0.76	0.00	-131.70	-5.36	-48.69	366	392	48	
14	2015	1087	1916	1516	1940	0.00	-3.07	-0.01	0.00	-5.48	-0.26	0.00	-131.70	3.20	-42.57	321	346	94	
15	2177	1122	2094	1554	1940	0.00	-2.95	0.04	0.00	-0.56	-0.04	0.00	-131.70	6.70	-36.96	276	301	139	
16	2340	1150	2274	1585	1940	0.00	-2.84	0.07	0.00	0.00	0.00	0.00	-131.70	9.54	-31.76	234	260	180	
17	2505	1172	2454	1609	1940	0.00	-2.76	0.11	0.00	0.00	0.00	0.00	-131.70	12.30	-26.95	195	221	219	
18	2669	1187	2636	1626	1940	0.00	-2.69	0.14	0.00	0.00	0.00	0.00	-131.70	14.99	-22.55	160	186	254	
19	2835	1197	2818	1637	1940	0.03	-2.65	0.19	-0.00	0.00	0.00	0.00	-131.73	17.64	-18.58	129	155	285	
20	3000	1200	3000	1640	1940	0.01	-2.63	0.21	-0.00	0.00	0.00	0.00	-131.74	20.27	-15.02	101	127	313	

Click here to lean how to read table of results

Table of results

- Basically, if there are *** in the last column, the thrust line touches the edge of the arch or falls outside the arch. So if you see more than 1 consecutive line showing ***, the thrust line falls outside the arch and we have failure if no backing, with full backing height and width it is unlikely have failure mechanism as bridge is very sound.

- The horizontal component of thrust at the springings (per metre width) can be read directly from the first and last rows of the span data, in Fx total. Similarly for vertical loads from Fz total.

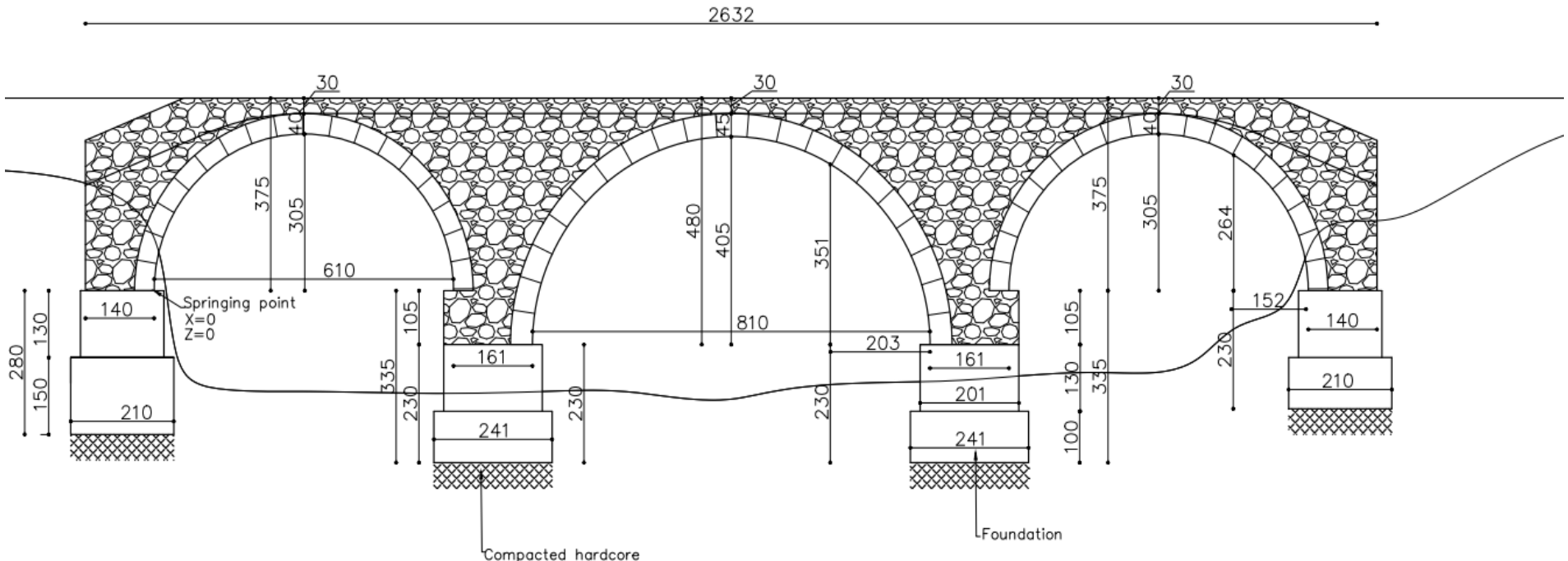
Quiz 2

Quiz number 2

1. Analyze the structural capacity of Mkeha stone arch bridge. Use the following information

i. Live load at rest
ii. Factor of safety for dead loads 1.0

iii. Factor of safety for live load you can adjust to suit your analysis.
iv. Shear test 210KN/m2



Any Questions!

Link to design manual and other related documents

Stone Arch Bridge Association

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- https://stonearchbridges.org/

End

Thank you all for your time