First Semester Examination
2017/2018 Academic Session

January 2018

EAS664 – Principle of Structural Design

Duration : 2 hours

Please check that this examination paper consists of SEVEN (7) pages of printed material before you begin the examination.

Instructions: Answer **FOUR (4)** questions in this examination paper.

All questions must be answered in English.

1. (a) The occurrence of structural damage by strong wind is increasing in the recent years. As a structural engineer, discuss **FOUR (4)** possible factors influencing the wind design calculation in the code of practices.

[8 marks]

(b) A 20-storey rigid framed building with setback as shown in **Figure 1** is located in Zone 1 with terrain category 2 according to MS1553:2002. The interstorey height is 3 m and the frames are spaced at 8 m centre to centre. Estimate the value of design wind pressure on the wind ward direction at the top floor of the frame according to MS1553:2002. Indicate all the assumed values used in the calculation. Design data can be extracted from MS1553 (2002).

[17 marks]

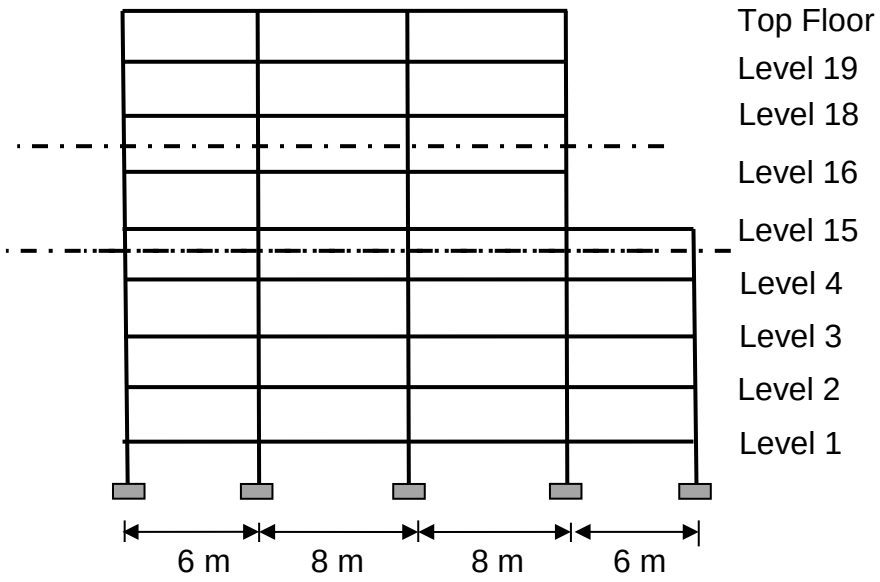


Figure 1

2. (a) Discuss the following structural forms and floor systems in a high-rise building:-

i. Shear wall structures
ii. Braced-frame structures
iii. Infilled-frame structures
iv. Waffle flat slabs

[8 marks]

...3/-

(b) A 15-storey rigid frame as shown in **Figure 2** is subjected to wind pressure of 1.5 kN/m^2 throughout the height. The typical storey height is 3 m, giving a total height of 45 m. The frames are spaced at 7 m. Determine the member forces and moments of the top floor using Cantilever Method and the 13th floor using Portal Method.

[17 marks]

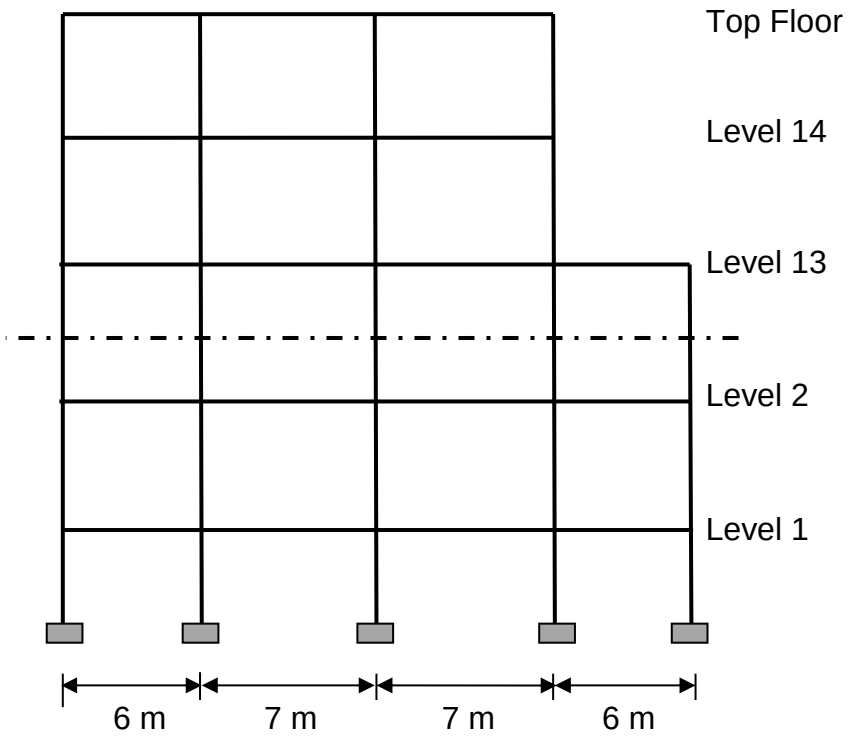


Figure 2

3. (a) Explain **THREE (3)** advantages of plastic design for steel structures.

[6 marks]

(b) **Figure 3** shows a continuous beam carrying the working loads. If the collapse load factor is 1.4, propose the optimum design for the beam shown using plastic method. Assume the material is mild steel with yield stress of 250 N/mm^2. Refer to the **Appendix** for the properties of section.

[19 marks]

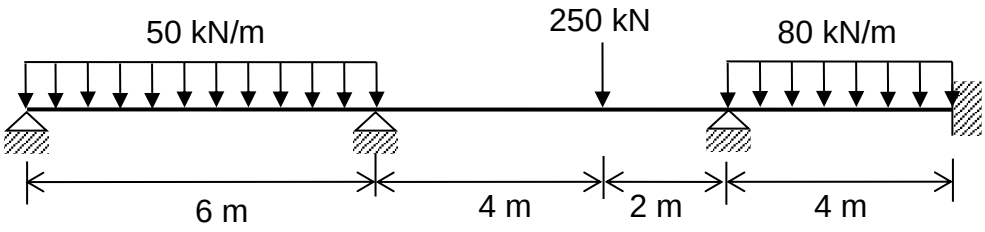


Figure 3

4. (a) Using the virtual work method, analyse a rectangular reinforced concrete slab of 10 m by 10 m which has two simply supported edges and two fixed edges and carries an ultimate uniformly distributed load w = 10 kN/m^2 as shown in **Figure 4.**

[10 marks]

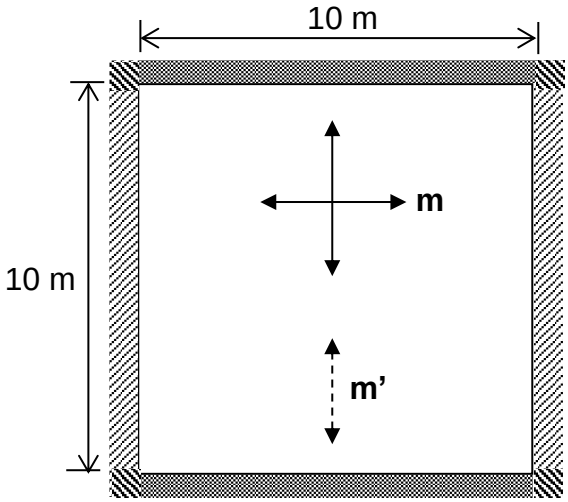


Figure 4

(b) **Figure 5** shows a reinforced concrete framed building. The beams are 125 mm wide by 230 mm deep. Column sections are 230 mm by 230 mm elsewhere. The dead load per unit area of floor slabs (125 mm thick) including screeding and plastering is 4.8 kN/m^2. Assume full height brickwall of 115 mm thick is constructed on the beams from the ground to top floors. The density of reinforced concrete and brickwall are 24 kN/m^3 and 18 kN/m^3, respectively. The building has 5% damping and it is designed for Ductility Class Medium (DCM). The peak ground acceleration at the site is 0.15 g. The average shear wave velocity in the top 30 m is 200 m/s. The land is of high intensity characterized by earthquake with a surface wave magnitude smaller than 5.5. The known seismic source is located more than 50 km away from the site. Determine the seismic forces for Frame A-A in accordance with EC8.

[15 marks]

...5/-

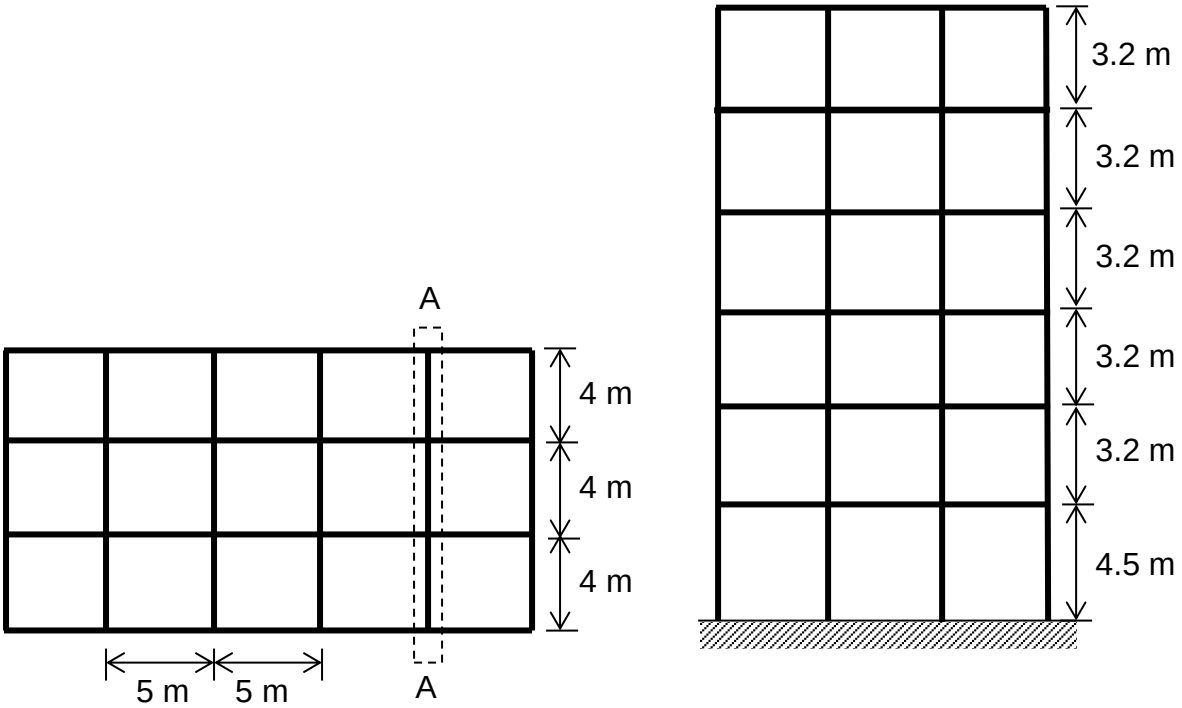
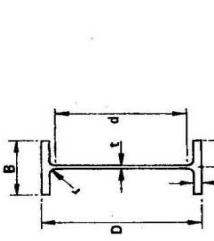


Figure 5

Appendix

UNIVERSAL BEAMS
To BS4: Part 1



Designation		Depth Of Section	Width Of Section	Thickness		Root Radius	Depth Between Fillets	Ratios For Local Buckling		Second Moment Of Area		Radius Of Gyration		Elastic Modulus		Plastic Modulus		Buckling Parameter	Torsional Index	Warping Constant	Torsional Constant	Area of Section
Serial Size	Mass Per Metre	D	B	Web t	Flange T	r	d	Flange b/T	Web d/t	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	u	x	H	J	A
mm	kg	mm	mm	mm	mm	mm	mm			cm⁴	cm⁴	cm	cm	cm³	cm³	cm³	cm³			dm⁶	cm⁴	cm²
914x419	388	920.5	420.5	21.5	36.6	24.1	799.1	5.74	37.2	719000	45400	38.1	9.58	15600	2160	17700	3340	0.884	26.7	88.7	1730	494
	343	911.4	418.5	19.4	32.0	24.1	799.1	6.64	41.2	625000	39200	37.8	9.46	13700	1870	15500	2890	0.883	30.1	75.7	1190	437
914x305	289	926.6	307.8	19.6	32.0	19.1	824.5	4.81	42.1	505000	15600	37.0	6.51	10900	1010	12600	1600	0.867	31.9	31.2	929	369
	253	918.5	305.5	17.3	27.9	19.1	824.5	5.47	47.7	437000	13300	36.8	6.42	9510	872	10900	1370	0.866	36.2	26.4	627	323
	224	910.3	304.1	15.9	23.9	19.1	824.5	6.36	51.9	376000	11200	36.3	6.27	8260	738	9520	1160	0.861	41.3	22.0	421	285
	201	903.0	303.4	15.2	20.2	19.1	824.5	7.51	54.2	326000	9430	35.6	6.06	7210	621	8360	983	0.853	46.8	18.4	293	256
838x292	226	850.9	293.8	16.1	26.8	17.8	761.7	5.48	47.3	340000	11400	34.3	6.27	7990	773	9160	1210	0.87	35.0	19.3	514	288
	194	840.7	292.4	14.7	21.7	17.8	761.7	6.74	51.8	279000	9070	33.6	6.06	6650	620	7650	974	0.862	41.6	15.2	307	247
	176	834.9	291.6	14.0	18.8	17.8	761.7	7.76	54.4	246000	7790	33.1	5.90	5890	534	6810	842	0.856	46.5	13.0	222	224
762x267	197	769.6	268.0	15.6	25.4	16.5	685.8	5.28	44.0	240000	8170	30.9	5.71	6230	610	7170	959	0.869	33.2	11.3	405	251
	173	762.0	266.7	14.3	21.6	16.5	685.8	6.17	48.0	205000	6850	30.5	5.57	5390	513	6200	807	0.864	38.1	9.38	267	220
	147	753.9	265.3	12.9	17.5	16.5	685.8	7.58	53.2	169000	5470	30.0	5.39	4480	412	5170	649	0.857	45.1	7.41	161	188
686x254	170	692.9	255.8	14.5	23.7	15.2	615.1	5.40	42.4	170000	6620	28.0	5.53	4910	518	5620	810	0.872	31.8	7.41	307	217
	152	687.6	254.5	13.2	21.0	15.2	615.1	6.06	46.6	150000	5780	27.8	5.46	4370	454	5000	710	0.871	35.5	6.42	219	194
	140	683.5	253.7	12.4	19.0	15.2	615.1	6.88	49.6	136000	5180	27.6	5.38	3990	408	4560	638	0.868	38.7	5.72	169	179
	125	677.9	253.0	11.7	16.2	15.2	615.1	7.81	52.6	118000	4380	27.2	5.24	3480	346	4000	542	0.862	43.9	4.79	116	160
610x305	238	633.0	311.5	18.6	31.4	16.5	537.2	4.96	28.9	208000	15800	26.1	7.22	6560	1020	7460	1570	0.886	21.1	14.3	788	304
	179	617.5	307.0	14.1	23.6	16.5	537.2	6.50	38.1	152000	11400	25.8	7.08	4910	743	5520	1140	0.886	27.5	10.1	341	228
	149	609.6	304.8	11.9	19.7	16.5	537.2	7.74	45.1	125000	9300	25.6	6.99	4090	610	4570	937	0.886	32.5	8.09	200	190
610x229	140	617.0	230.1	13.1	22.1	12.7	547.3	5.21	41.8	112000	4510	25.0	5.03	3630	392	4150	612	0.875	30.5	3.99	217	178
	125	611.9	229.0	11.9	19.6	12.7	547.3	5.84	46.0	98600	3930	24.9	4.96	3220	344	3680	536	0.873	34.0	3.45	155	160
	113	607.3	228.2	11.2	17.3	12.7	547.3	6.60	48.9	87400	3440	24.6	4.88	2880	301	3290	470	0.87	37.9	2.99	112	144
	101	602.2	227.6	10.6	14.8	12.7	547.3	7.69	51.6	75700	2910	24.2	4.75	2510	256	2880	400	0.863	43.0	2.51	77.2	129
533x210	122	544.6	211.9	12.8	21.3	12.7	476.5	4.97	37.2	76200	3390	22.1	4.67	2800	320	3200	501	0.876	27.6	2.32	180	156
	109	539.5	210.7	11.6	18.8	12.7	476.5	5.60	41.1	66700	2940	21.9	4.60	2470	279	2820	435	0.875	30.9	1.99	126	139
	101	536.7	210.1	10.9	17.4	12.7	476.5	6.04	43.7	61700	2690	21.8	4.56	2300	257	2620	400	0.874	33.1	1.82	102	129
	92	533.1	209.3	10.2	15.6	12.7	476.5	6.71	46.7	55400	2390	21.7	4.51	2080	229	2370	366	0.872	36.4	1.60	76.2	118
	82	528.3	208.7	9.6	13.2	12.7	476.5	7.91	49.6	47500	2010	21.3	4.38	1800	192	2060	300	0.865	41.6	1.33	51.3	104
457x191	98	467.4	192.8	11.4	19.6	10.2	407.9	4.92	35.8	45700	2340	19.1	4.33	1960	243	2230	378	0.88	25.8	1.17	121	125
	89	463.6	192.0	10.6	17.7	10.2	407.9	5.42	38.5	41000	2090	19.0	4.28	1770	217	2010	338	0.879	28.3	1.04	90.5	114
	82	460.2	191.3	9.9	16.0	10.2	407.9	5.98	41.2	37100	1870	18.8	4.23	1610	196	1830	304	0.877	30.9	0.923	69.2	105
	74	457.2	190.5	9.1	14.5	10.2	407.9	6.57	44.8	33400	1670	18.7	4.19	1460	175	1660	272	0.876	33.9	0.819	52.0	95.0
	67	453.6	189.9	8.5	12.7	10.2	407.9	7.48	48.0	29400	1450	18.5	4.12	1300	153	1470	237	0.873	37.9	0.706	37.1	85.4

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UNIVERSAL BEAMS

DIMENSIONS | PROPERTIES

Designation: Serial Size (mm)	Designation: Mass Per Metre (kg)	Depth Of Section D (mm)	Width Of Section B (mm)	Thickness Web t (mm)	Thickness Flange T (mm)	Root Radius r (mm)	Depth Between Fillets d (mm)	Ratios For Local Buckling Flange b/T	Ratios For Local Buckling Web d/t	Second Moment Of Area Axis x-x (cm⁴)	Second Moment Of Area Axis y-y (cm⁴)	Radius Of Gyration Axis x-x (cm)	Radius Of Gyration Axis y-y (cm)	Elastic Modulus Axis x-x (cm³)	Elastic Modulus Axis y-y (cm³)	Plastic Modulus Axis x-x (cm³)	Plastic Modulus Axis y-y (cm³)	Buckling Parameter u	Torsional Index x	Warping Constant H (dm⁶)	Torsional Constant J (cm⁴)	Area of Section A (cm²)
457x152	82	465.1	153.5	10.7	18.9	10.2	407.0	4.06	38.0	36200	1140	18.6	3.31	1560	149	1800	235	0.872	27.3	0.569	89.3	104
	74	461.3	152.7	9.9	17.0	10.2	407.0	4.49	41.1	32400	1010	18.5	3.26	1410	133	1620	209	0.87	30.0	0.499	66.6	95.0
	67	457.2	151.9	9.1	15.0	10.2	407.0	5.06	44.7	28600	878	18.3	3.21	1250	116	1440	182	0.867	33.6	0.429	47.5	85.4
	60	454.7	152.9	8.0	13.3	10.2	407.7	5.75	51.0	25500	794	18.3	3.23	1120	104	1280	163	0.869	37.5	0.387	33.6	75.9
	52	449.8	152.4	7.6	10.9	10.2	407.7	6.99	53.6	21300	645	17.9	3.11	949	84.6	1090	133	0.859	43.9	0.311	21.3	66.5
406x178	74	412.8	179.7	9.7	16.0	10.2	360.5	5.62	37.2	27300	1540	17.0	4.03	1320	172	1500	267	0.881	27.6	0.608	63.0	95.0
	67	409.4	178.8	8.8	14.3	10.2	360.5	6.25	41.0	24300	1360	16.9	4.00	1190	153	1350	237	0.88	30.5	0.533	46.0	85.5
	60	406.4	177.8	7.8	12.8	10.2	360.5	6.95	46.2	21500	1200	16.8	3.97	1060	135	1190	208	0.88	33.9	0.464	32.9	76.0
	54	402.6	177.6	7.6	10.9	10.2	360.5	8.15	47.4	18600	1020	16.5	3.85	925	114	1050	177	0.872	38.5	0.39	22.7	68.4
406x140	46	402.3	142.4	6.9	11.2	10.2	359.7	6.36	52.1	15600	539	16.3	3.02	778	75.7	888	118	0.87	38.8	0.206	19.2	59.0
	39	397.3	141.8	6.3	8.6	10.2	359.7	8.24	57.1	12500	411	15.9	2.89	627	58.0	721	91.1	0.859	47.4	0.155	10.6	49.4
356x171	67	364.0	173.2	9.1	15.7	10.2	312.3	5.52	34.3	19500	1360	15.1	3.99	1070	157	1210	243	0.887	24.4	0.413	55.5	85.4
	57	358.6	172.1	8.0	13.0	10.2	312.3	6.62	39.0	16100	1110	14.9	3.92	896	129	1010	199	0.884	28.9	0.331	33.1	72.2
	51	355.6	171.5	7.3	11.5	10.2	312.3	7.46	42.8	14200	968	14.8	3.87	796	113	895	174	0.882	32.2	0.286	23.6	64.6
	45	352.0	171.0	6.9	9.7	10.2	312.3	8.81	45.3	12100	812	14.6	3.78	687	95.0	774	147	0.875	36.9	0.238	15.7	57.0
356x127	39	352.8	126.0	6.5	10.7	10.2	311.2	5.89	47.9	10100	357	14.3	2.69	572	56.6	654	88.7	0.872	35.3	0.104	14.9	49.4
	33	348.5	125.4	5.9	8.5	10.2	311.2	7.38	52.7	8200	280	14.0	2.59	471	44.7	540	70.2	0.864	42.2	0.081	8.68	41.8
305x165	54	310.9	166.8	7.7	13.7	8.9	265.7	6.09	34.5	11700	1060	13.1	3.94	753	127	845	195	0.89	23.7	0.234	34.5	68.4
	46	307.1	165.7	6.7	11.8	8.9	265.7	7.02	39.7	9950	897	13.0	3.90	648	108	723	166	0.89	27.2	0.196	22.3	58.9
	40	303.8	165.1	6.1	10.2	8.9	265.7	8.09	43.6	8520	763	12.9	3.85	561	92.4	624	141	0.888	31.1	0.164	14.7	51.5
305x127	48	310.4	125.2	8.9	14.0	8.9	264.6	4.47	29.7	9500	460	12.5	2.75	612	73.5	706	116	0.874	23.3	0.101	31.4	60.8
	42	306.6	124.3	8.0	12.1	8.9	264.6	5.14	33.1	8140	388	12.4	2.70	531	62.5	610	98.2	0.872	26.5	0.0842	21.0	53.2
	37	303.8	123.5	7.2	10.7	8.9	264.6	5.77	36.7	7160	337	12.3	2.67	472	54.6	540	85.7	0.871	29.6	0.0724	14.9	47.5
305x102	33	312.7	102.4	6.6	10.8	7.6	275.9	4.74	41.8	6490	193	12.5	2.15	415	37.8	480	59.8	0.866	31.7	0.0441	12.1	41.8
	28	308.9	101.9	6.1	8.9	7.6	275.9	5.72	45.2	5420	157	12.2	2.08	351	30.8	407	48.9	0.858	37.0	0.0353	7.63	36.3
	25	304.8	101.6	5.8	6.8	7.6	275.9	7.47	47.6	4390	120	11.8	1.96	288	23.6	338	38.0	0.844	43.8	0.0266	4.65	31.4
254x146	43	259.6	147.3	7.3	12.7	7.6	218.9	5.80	30.0	6560	677	10.9	3.51	505	92.0	568	141	0.889	21.1	0.103	24.1	55.1
	37	256.0	146.4	6.4	10.9	7.6	218.9	6.72	34.2	5560	571	10.8	3.47	434	78.1	485	120	0.889	24.3	0.0858	15.5	47.5
	31	251.5	146.1	6.1	8.6	7.6	218.9	8.49	35.9	4440	449	10.5	3.35	353	61.5	396	94.5	0.879	29.4	0.0662	8.73	40.0
254x102	28	260.4	102.1	6.4	10.0	7.6	225.1	5.10	35.2	4010	178	10.5	2.22	308	34.9	353	54.8	0.873	27.5	0.0279	9.64	36.2
	25	257.0	101.9	6.1	8.4	7.6	225.1	6.07	36.9	3410	148	10.3	2.14	265	29.0	306	45.8	0.864	31.4	0.0228	6.45	32.2
	22	254.0	101.6	5.8	6.8	7.6	225.1	7.47	38.8	2870	120	10.00	2.05	226	23.6	262	37.5	0.854	35.9	0.0183	4.31	28.4
203x133	30	206.8	133.8	6.3	9.6	7.6	172.3	6.97	27.3	2890	384	8.72	3.18	279	57.4	313	88.1	0.882	21.5	0.0373	10.2	38.0
	25	203.2	133.4	5.8	7.8	7.6	172.3	8.55	29.7	2360	310	8.54	3.10	232	46.4	260	71.4	0.876	25.4	0.0295	6.12	32.3
203x102	23	203.2	101.6	5.2	9.3	7.6	169.4	5.46	32.6	2090	163	8.49	2.37	206	32.1	232	49.5	0.89	22.6	0.0153	6.87	29.0
178x102	19	177.8	101.6	4.7	7.9	7.6	146.8	6.43	31.2	1360	138	7.49	2.39	153	27.2	171	41.9	0.889	22.6	0.00998	4.37	24.2
152x89	16	152.4	88.9	4.6	7.7	7.6	121.8	5.77	26.5	838	90.4	6.40	2.10	110	20.3	124	31.4	0.889	19.5	0.00473	3.61	20.5
127x76	13	127.0	76.2	4.2	7.6	7.6	96.6	5.01	23.0	477	56.2	5.33	1.83	75.1	14.7	85	22.7	0.893	16.2	0.002	2.92	16.8

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