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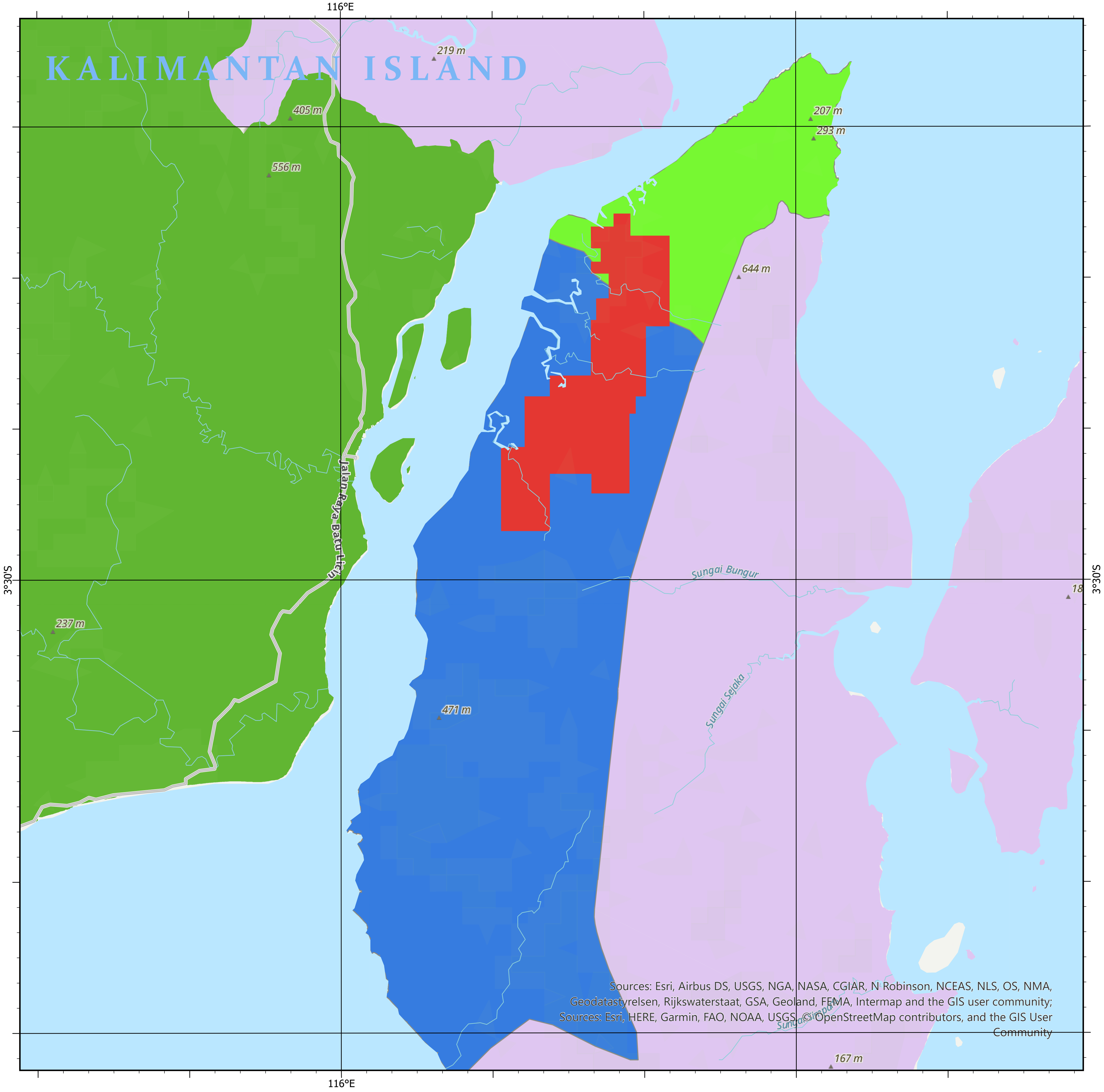
APPENDICES

APPENDIX A

WIUP MAP OF PT SEBUKU TANJUNG COAL

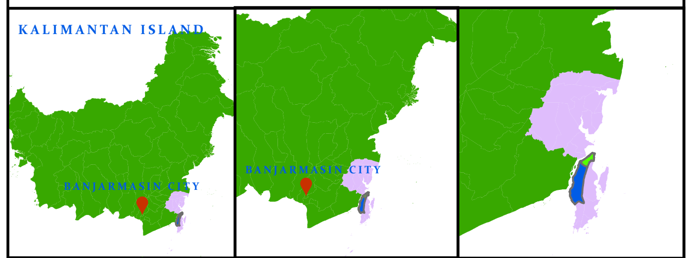


N
W E
S

4 2 0 4 8 12 16
Kilometers

Legend
- WIUP
- Pulaulaut Tengah District
- Pulaulaut Utara District
- Kotabaru Regency
- Kalimantan Island

Cartographic Information
Projection: UTM, Zone 50S
Datum Unit: WGS-84
Sheet Size : A3



MINING ENGINEERING DEPARTMENT
FACULTY OF ENGINEERING
HASANUDDIN UNIVERSITY
2022

THESIS

COAL PRODUCTION FAILURE RISK IDENTIFICATION USING FUZZY FMEA (FAILURE MODE EFFECT ANALYSIS) AT PT SEBUKU TANJUNG COAL SOUTH KALIMANTAN

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WIUP OF PT SEBUKU TANJUNG COAL

APPENDIX	PAGE
A	90

APPENDIX B
LOADER CYCLE TIME

Date: 9th January 2021 Unit: Second

Time	Load Count	Loader								Hauler	Passing	Loader type
		Loading time				Job Eficiency						
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
09.25 - 10.25	1				3	330	746	0	166	Hyundai	10	Sany SY500H
	2	16	6	6	5							
	3	16	7	6	6							
	4	14	7	5	6							
	5	15	7	8	8							
	6	18	11	6	5							
	7	19	6	6	6							
	8	16	6	8	8							
	9	17	6	6	6							
	10	17	6	6	10							
	1				3	305	287	49	624	Hino	10	
	2	14	6	5	5							
	3	18	6	6	5							
	4	15	6	6	5							
	5	15	6	6	7							
	6	16	6	6	7							
	7	15	6	5	6							
	8	15	6	6	6							
	9	15	6	6	7							
	10	10	6	6	15							
	1				3	285	190	46	0	Hino	11	
	2	10	6	5	3							
	3	12	4	5	4							
	4	13	4	5	4							
	5	14	4	6	4							
	6	14	4	5	5							
	7	15	4	5	5							
	8	13	4	5	4							
	9	14	3	5	4							
	10	14	4	5	5							
	11	10	4	5	23							
	1				3	268	159	145	0	Hino	10	
	2	11	6	4	3							
	3	10	8	4	4							
	4	13	5	5	4							
	5	11	6	4	4							
	6	11	6	4	5							

Time	Load Count	Loader								Hauler	Passing	Loader type
		Loading time				Job Eficiency						
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	7	10	5	5	5							
	8	12	5	5	5							
	9	10	7	5	4							
	10	10	7	5	37							
	1				3							
	2	6	4	4	4							
	3	15	4	4	4							
	4	15	4	4	4							
	5	12	4	4	7	262	105	0	0	Hyundai	10	
	6	17	4	4	6							
	7	24	4	4	6							
	8	20	5	5	5							
	9	10	5	5	4							
	10	7	5	5	15							
	1				3							
	2	8	8	8	4							
	3	10	8	8	5							
	4	10	8	8	5							
	5	12	8	8	5							
	6	13	8	8	5	376	65	35	0	Hyundai	12	
	7	13	8	9	5							
10.36 - 11.36	8	7	9	9	4							
	9	8	9	9	4							
	10	8	9	9	4							
	11	10	9	9	5							
	12	5	9	9	36							
	1				3							
	2	20	4	4	4							
	3	15	4	4	3							
	4	20	5	5	4							
	5	28	5	5	5							
	6	39	5	5	4	424	328	45	0	Hyundai	12	
	7	14	5	5	6							
	8	46	5	5	6							
	9	20	5	5	7							
	10	25	5	5	4							
	11	22	5	5	4							
	12	8	5	5	11							
	1				3	338	212	68	0	Hyundai	12	
	2	7	4	4	4							

Time	Load Count	Loader								Hauler	Passing	Loader type
		Loading time				Job Eficiency						
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	3	11	4	4	4							
	4	11	4	5	4							
	5	10	5	5	4							
	6	38	5	5	6							
	7	26	5	5	7							
	8	10	5	5	7							
	9	10	5	5	4							
	10	9	5	5	3							
	11	14	5	5	4							
	12	10	5	5	27							
	1				3							
	2	10	4	4	4							
	3	13	4	4	4							
	4	20	4	4	4							
	5	35	4	4	6							
	6	12	4	4	5							
	7	15	4	4	8	349	68	24	0	Hyundai	13	
	8	8	4	4	4							
	9	18	4	4	4							
	10	21	4	4	6							
	11	15	5	5	5							
	12	7	5	5	4							
	13	7	5	5	9							
	1				3							
	2	15	5	5	4							
	3	17	5	5	4							
	4	47	5	6	5							
	5	34	6	6	4	350	71	36	0	Hino	10	
	6	11	6	6	8							
	7	23	6	6	4							
	8	16	6	6	4							
	9	23	6	6	6							
	10	9	6	6	10							
	1				3							
	2	30	4	4	4							
	3	18	4	4	4							
	4	10	4	4	6	382	0	62	0	Hyundai	11	
	5	40	4	4	4							
	6	33	5	5	5							
	7	20	5	5	7							

Time	Load Count	Loader								Hauler	Passing	Loader type
		Loading time				Job Eficiency						
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	8	21	5	5	5							
	9	37	5	5	5							
	10	10	5	5	4							
	11	6	5	5	18							
	1				3	246	97	0	0	Hino	10	
	2	6	3	3	4							
	3	15	3	3	4							
	4	15	3	3	4							
	5	12	3	3	7							
	6	17	3	3	6							
	7	24	4	4	6							
	8	20	4	4	5							
	9	10	4	4	4							
	10	7	4	4	15							
14.20 - 15.20	1				3	259	287	944	0	Hino	12	
	2	8	3	3	4							
	3	10	3	3	5							
	4	10	3	3	5							
	5	12	3	3	5							
	6	13	3	3	5							
	7	13	3	3	5							
	8	7	3	3	4							
	9	8	3	3	4							
	10	8	3	3	4							
	11	10	4	4	5							
	12	5	4	4	36							
	1				3	368	0	63	0	Hino	12	
	2	20	2	2	4							
	3	15	2	2	3							
	4	20	2	2	4							
	5	28	2	2	5							
	6	39	2	2	4							
	7	14	2	2	6							
	8	46	2	2	6							
	9	20	2	2	7							
	10	25	3	3	4							
	11	22	3	3	4							
	12	8	3	3	11							
	1				3	306	12	156	0	Hyundai	12	
	2	7	3	3	4							

Time	Load Count	Dig time	Swing time: Empty	Swing time: Load	Load time	Working Time	Sorting	Spotting	Waiting	Hauler	Passing	Loader type
		Loader										
		Loading time				Job Eficiency						
							Loss Time					
	3	11	3	3	4							
	4	11	3	3	4							
	5	10	3	3	4							
	6	38	3	3	6							
	7	26	3	3	7							
	8	10	3	3	7							
	9	10	4	3	4							
	10	9	4	4	3							
	11	14	4	4	4							
	12	10	4	4	27							
	1				3							
	2	10	1	1	4							
	3	13	1	1	4							
	4	20	1	1	4							
	5	35	1	1	4							
	6	12	1	1	5							
	7	13	1	1	4	263	65	130	0	Hino	13	
	8	8	1	1	4							
	9	18	1	1	4							
	10	21	1	1	6							
	11	15	1	1	5							
	12	7	1	1	4							
	13	7	1	1	9							
	1				3							
	2	15	5	5	4							
	3	17	5	5	4							
	4	47	5	6	5							
	5	34	6	6	4	254	0	150	0	Hyundai	10	
	6	11	6	6	8							
	7	23	6	6	4							
	8	16	6	6	4							
	9	23	6	6	6							
	10	9	6	6	10							

Date: 11th January 2021 Unit: Second

Time	Load Count	Loader									Hauler	Loader
		Loading time				Job Eficiency				Passing		
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
09.45 - 10.45	1				3	320.6	0	0	0	15	Hyundai	Kobelco SK330
	2	8	3.63	3.63	5							
	3	8	3.63	3.63	3							
	4	6	3.63	3.63	3							
	5	7	3.63	3.63	3							
	6	7	3.63	3.63	3							
	7	6	3.63	3.63	3							
	8	8	3.63	3.63	3							
	9	7	3.63	3.63	4							
	10	11	3.63	3.63	4							
	11	8	3.63	3.63	3							
	12	50	3.63	3.63	3							
	13	10	3.63	3.63	3							
	14	4	3.63	3.63	3							
	15	8	3.63	3.63	25							
	1				3	319.6	1443.8	79.8	25.8	17	Hyundai	
	2	4	3.58	3.58	3							
	3	8	3.58	3.58	3							
	4	8	3.58	3.58	3							
	5	7	3.58	3.58	3							
	6	6	3.58	3.58	3							
	7	10	3.58	3.58	3							
	8	9	3.58	3.58	3							
	9	8	3.58	3.58	3							
	10	8	3.58	3.58	3							
	11	10	3.58	3.58	3							
	12	8	3.58	3.58	3							
	13	8	3.58	3.58	3							
	14	8	3.58	3.58	3							
	15	10	3.58	3.58	3							
	16	15	3.58	3.58	8							
	17	6	3.58	3.58	19							
	1				3	241.6	0	27.8	151.8	14	Articulary	
	2	9	3.52	3.52	3							
	3	5	3.52	3.52	3							
	4	6	3.52	3.52	3							
	5	12	3.52	3.52	3							
	6	17	3.52	3.52	3							
	7	8	3.52	3.52	3							

Time	Load Count	Loader									Hauler	Loader
		Loading time				Job Eficiency				Passing		
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	8	7	3.52	3.52	3							
	9	7	3.52	3.52	3							
	10	7	3.52	3.52	3							
	11	8	3.52	3.52	3							
	12	5	3.52	3.52	3							
	13	8	3.52	3.52	4							
	14	6	3.52	3.52	5							
	1				3	258.6	31.8	83.8	118.8	14	Articulary	
	2	7	3.91	3.91	3							
	3	7	3.91	3.91	3							
	4	15	3.91	3.91	3							
	5	8	3.91	3.91	3							
	6	6	3.91	3.91	3							
	7	8	3.91	3.91	3							
	8	8	3.91	3.91	3							
	9	10	3.91	3.91	3							
	10	8	3.91	3.91	3							
	11	14	3.91	3.91	3							
	12	8	3.91	3.91	3							
	13	6	3.91	3.91	3							
	14	10	3.91	3.91	3							
	1				3	351.6	125.8	18.8	0	16	Hyundai	
	2	5	4.59	4.59	3							
	3	6	4.59	4.59	3							
	4	16	4.59	4.59	3							
	5	14	4.59	4.59	4							
	6	5	4.59	4.59	3							
	7	20	4.59	4.59	3							
	8	9	4.59	4.59	3							
	9	16	4.59	4.59	3							
	10	7	4.59	4.59	3							
	11	9	4.59	4.59	3							
	12	11	4.59	4.59	3							
	13	14	4.59	4.59	3							
	14	13	4.59	4.59	3							
	15	8	4.59	4.59	3							
	16	10	4.59	4.59	5							
14.15 - 15.15	1				3	301.07	0	0	0	14	Izusu	Sany SY365H
	2	8	4.50	4.50	3							
	3	9	4.50	4.50	3							

Time	Load Count	Loader										Loader
		Loading time				Job Eficiency				Passing	Hauler	
		Dig time	Swing time Empty	Swing time Load	Load time	Working Time	Loss Time Sorting	Loss Time Spotting	Loss Time Waiting			
	4	5	4.50	4.50	3							
	5	5	4.50	4.50	3							
	6	10	4.50	4.50	3							
	7	10	4.50	4.50	4							
	8	9	4.50	4.50	3							
	9	9	4.50	4.50	4							
	10	7	4.50	4.50	3							
	11	8	4.50	4.50	3							
	12	12	4.50	4.50	3							
	13	11	4.50	4.50	4							
	14	9	4.50	4.50	30							
	1				3							
	2	5	5.21	5.21	3							
	3	6	5.21	5.21	3							
	4	11	5.21	5.21	3							
	5	8	5.21	5.21	3							
	6	7	5.21	5.21	3							
	7	8	5.21	5.21	3	319.07	0	142.61	0	13	Hino	
	8	8	5.21	5.21	3							
	9	7	5.21	5.21	4							
	10	19	5.21	5.21	3							
	11	26	5.21	5.21	3							
	12	11	5.21	5.21	3							
	13	11	5.21	5.21	30							
	1				3							
	2	10	4.79	4.79	3							
	3	12	4.79	4.79	3							
	4	12	4.79	4.79	3							
	5	6	4.79	4.79	3							
	6	18	4.79	4.79	3							
	7	15	4.79	4.79	3	330.07	16.61	94.61	0	13	Hino	
	8	7	4.79	4.79	3							
	9	14	4.79	4.79	3							
	10	10	4.79	4.79	3							
	11	9	4.79	4.79	3							
	12	10	4.79	4.79	3							
	13	9	4.79	4.79	47							
	1				3							
	2	9	4.08	4.08	3	299.07	0	95.61	0	14	Hino	
	3	9	4.08	4.08	2							

Time	Load Count	Loader										Loader
		Loading time				Job Eficiency						
		Dig time	Swing time		Load time	Working Time	Loss Time			Passing	Hauler	
			Empty	Load			Sorting	Spotting	Waiting			
	4	5	4.08	4.08	2							
	5	7	4.08	4.08	2							
	6	7	4.08	4.08	3							
	7	9	4.08	4.08	2							
	8	17	4.08	4.08	3							
	9	9	4.08	4.08	2							
	10	6	4.08	4.08	3							
	11	10	4.08	4.08	3							
	12	10	4.08	4.08	2							
	13	8	4.08	4.08	2							
	14	5	4.08	4.08	50							
	1				2							
	2	8	4.84	4.84	2							
	3	7	4.84	4.84	2							
	4	9	4.84	4.84	3							
	5	10	4.84	4.84	3							
	6	7	4.84	4.84	2							
	7	9	4.84	4.84	4	301.07	815.61	0	216.61	13	Hino	
	8	11	4.84	4.84	3							
	9	10	4.84	4.84	3							
	10	6	4.84	4.84	5							
	11	8	4.84	4.84	3							
	12	6	4.84	4.84	3							
	13	8	4.84	4.84	51							
	1				2							
	2	8	3.84	3.84	2							
	3	8	3.84	3.84	2							
	4	6	3.84	3.84	2							
	5	10	3.84	3.84	2							
	6	9	3.84	3.84	2							
	7	7	3.84	3.84	2	237.07		33.61		13	Izusu	
	8	7	3.84	3.84	2							
	9	7	3.84	3.84	3							
	10	9	3.84	3.84	2							
	11	4	3.84	3.84	2							
	12	10	3.84	3.84	2							
	13	6	3.84	3.84	29							
	1				3							
	2	8	2.79	2.79	3	259.07		6.61	131.61	13	Izusu	
	3	10	2.79	2.79	2							

Time	Load Count	Loader										Loader
		Loading time				Job Eficiency				Passing	Hauler	
		Dig time	Swing time Empty	Swing time Load	Load time	Working Time	Loss Time Sorting	Loss Time Spotting	Loss Time Waiting			
	4	6	2.79	2.79	2							
	5	8	2.79	2.79	7							
	6	6	2.79	2.79	2							
	7	5	2.79	2.79	3							
	8	10	2.79	2.79	2							
	9	7	2.79	2.79	3							
	10	10	2.79	2.79	4							
	11	8	2.79	2.79	2							
	12	24	2.79	2.79	2							
	13	6	2.79	2.79	49							
	1				2							
	2	9	5.29	5.29	2							
	3	10	5.29	5.29	2							
	4	10	5.29	5.29	2							
	5	16	5.29	5.29	3							
	6	18	5.29	5.29	3							
	7	10	5.29	5.29	4	305.89	0	0	0	13	Hino	
	8	8	5.29	5.29	3							
	9	9	5.29	5.29	2							
	10	8	5.29	5.29	2							
	11	12	5.29	5.29	2							
	12	12	5.29	5.29	2							
	13	11	5.29	5.29	17							
	1				2							
15.20 – 16.20	2	9	3.83	3.83	2							Sany SY365H
	3	9	3.83	3.83	2							
	4	11	3.83	3.83	3							
	5	10	3.83	3.83	2							
	6	32	3.83	3.83	2							
	7	7	3.83	3.83	2	310.89	272.89	114.89	0	13	Hino	
	8	11	3.83	3.83	3							
	9	13	3.83	3.83	2							
	10	11	3.83	3.83	2							
	11	8	3.83	3.83	3							
	12	13	3.83	3.83	3							
	13	11	3.83	3.83	46							
	1				2							
	2	18	1.65	1.65	2	261.89	0	44.89	0	14	Izusu	
	3	10	1.65	1.65	2							
	4	11	1.65	1.65	2							

Time	Load Count	Loader									Hauler	Loader
		Loading time				Job Eficiency				Passing		
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	5	6	1.65	1.65	2							
	6	13	1.65	1.65	2							
	7	14	1.65	1.65	2							
	8	7	1.65	1.65	2							
	9	9	1.65	1.65	3							
	10	11	1.65	1.65	2							
	11	7	1.65	1.65	2							
	12	15	1.65	1.65	3							
	13	13	1.65	1.65	2							
	14	11	1.65	1.65	46							
	1				2							
	2	10	3.20	3.20	2							
	3	11	3.20	3.20	2							
	4	11	3.20	3.20	3							
	5	10	3.20	3.20	3							
	6	10	3.20	3.20	3							
	7	7	3.20	3.20	2	262.89	0	98.89	0	13	Hino	
	8	10	3.20	3.20	2							
	9	20	3.20	3.20	2							
	10	10	3.20	3.20	3							
	11	11	3.20	3.20	3							
	12	12	3.20	3.20	2							
	13	11	3.20	3.20	24							
	1				2							
	2	16	3.12	3.12	2							
	3	9	3.12	3.12	2							
	4	12	3.12	3.12	2							
	5	17	3.12	3.12	2							
	6	9	3.12	3.12	2							
	7	11	3.12	3.12	3	292.89	0	94.89	0	13	Hino	
	8	7	3.12	3.12	2							
	9	22	3.12	3.12	2							
	10	8	3.12	3.12	2							
	11	15	3.12	3.12	2							
	12	11	3.12	3.12	2							
	13	14	3.12	3.12	42							
	1				2							
	2	10	3.90	3.90	2	264.89		6.89		12	Hino	
	3	11	3.90	3.90	2							
	4	8	3.90	3.90	3							

Time	Load Count	Loader										Loader
		Loading time				Job Eficiency				Passing	Hauler	
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	5	12	3.90	3.90	2							
	6	11	3.90	3.90	2							
	7	10	3.90	3.90	3							
	8	10	3.90	3.90	2							
	9	14	3.90	3.90	3							
	10	19	3.90	3.90	2							
	11	7	3.90	3.90	3							
	12	11	3.90	3.90	30							
	1				2							
	2	18	2.95	2.95	2							
	3	9	2.95	2.95	2							
	4	11	2.95	2.95	2							
	5	6	2.95	2.95	2							
	6	11	2.95	2.95	2							
	7	14	2.95	2.95	2	292.89	0	151.89	0	13	Izusu	
	8	12	2.95	2.95	2							
	9	10	2.95	2.95	3							
	10	13	2.95	2.95	2							
	11	14	2.95	2.95	2							
	12	12	2.95	2.95	2							
	13	9	2.95	2.95	58							
	1				2							
	2	9	3.95	3.95	2							
	3	10	3.95	3.95	2							
	4	10	3.95	3.95	3							
	5	11	3.95	3.95	2							
	6	12	3.95	3.95	3							
	7	6	3.95	3.95	2	322.89	0	114.89	0	13	Hyundai	
	8	11	3.95	3.95	2							
	9	11	3.95	3.95	2							
	10	12	3.95	3.95	3							
	11	23	3.95	3.95	2							
	12	36	3.95	3.95	3							
	13	11	3.95	3.95	38							
	1				2							
	2	17	3.91	3.91	2							
	3	11	3.91	3.91	2	297.89	0	86.89	0	13	Hyundai	
	4	9	3.91	3.91	2							
	5	11	3.91	3.91	2							
	6	12	3.91	3.91	2							

Time	Load Count	Loader											Loader
		Loading time				Job Eficiency							
		Dig time	Swing time		Load time	Working Time	Loss Time			Passing	Hauler		
			Empty	Load			Sorting	Spotting	Waiting				
	7	11	3.91	3.91	2								
	8	12	3.91	3.91	2								
	9	15	3.91	3.91	2								
	10	11	3.91	3.91	2								
	11	12	3.91	3.91	3								
	12	10	3.91	3.91	2								
	13	23	3.91	3.91	25								

Date: 30th January 2021 Unit: Second

Time	Load Count	Dig time	Swing time Empty	Swing time Load	Load time	Working Time	Loss Time Sorting	Loss Time Spotting	Loss Time Waiting	Passing	Hauler	Loader type
09.24 - 10.24	1				3	300,42	0	0	0	15	Hino	Kobelco SK330
	2	5	1,41	1,41	3							
	3	12	1,41	1,41	3							
	4	6	1,41	1,41	3							
	5	5	1,41	1,41	3							
	6	11	1,41	1,41	3							
	7	6	1,41	1,41	3							
	8	6	1,41	1,41	4							
	9	6	1,41	1,41	4							
	10	110	1,41	1,41	3							
	11	9	1,41	1,41	3							
	12	7	1,41	1,41	3							
	13	10	1,41	1,41	3							
	14	6	1,41	1,41	21							
	15	0	1,41	1,41	0							
	1				2	283,42	0	67,50	0	17	Hino	
	2	9	3,29	3,29	3							
	3	7	3,29	3,29	3							
	4	10	3,29	3,29	3							
	5	9	3,29	3,29	3							
	6	8	3,29	3,29	3							
	7	8	3,29	3,29	3							
	8	8	3,29	3,29	4							
	9	9	3,29	3,29	3							
	10	9	3,29	3,29	3							
	11	8	3,29	3,29	3							
	12	10	3,29	3,29	3							
	13	8	3,29	3,29	3							
	14	4	3,29	3,29	4							
	15	8	3,29	3,29	20							
	16	0	3,29	3,29	0							
	17	0	3,29	3,29	0							
	1				3	330,42	147,50	34,50	0	14	Hyundai	
	2	8	4,40	4,40	3							
	3	11	4,40	4,40	3							
	4	8	4,40	4,40	3							
	5	10	4,40	4,40	3							

Time	Load Count	Loader										
		Loading time				Job Eficiency				Passing	Hauler	Loader type
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	6	12	4,40	4,40	3							
	7	14	4,40	4,40	3							
	8	8	4,40	4,40	3							
	9	7	4,40	4,40	3							
	10	16	4,40	4,40	3							
	11	7	4,40	4,40	3							
	12	10	4,40	4,40	3							
	13	9	4,40	4,40	3							
	14	11	4,40	4,40	3							
	15	13	4,40	4,40	3							
	16	4	4,40	4,40	23							
	1				3							
	2	9	3,71	3,71	3							
	3	8	3,71	3,71	3							
	4	8	3,71	3,71	3							
	5	14	3,71	3,71	3							
	6	14	3,71	3,71	3							
	7	9	3,71	3,71	3							
	8	9	3,71	3,71	3	307,42	0	156,50	0	14	Izusu	
	9	8	3,71	3,71	3							
	10	6	3,71	3,71	3							
	11	7	3,71	3,71	3							
	12	10	3,71	3,71	3							
	13	8	3,71	3,71	4							
	14	16	3,71	3,71	3							
	15	4	3,71	3,71	38							
	1				3							
	2	12	5,01	5,01	3							
	3	8	5,01	5,01	3							
	4	12	5,01	5,01	3							
	5	12	5,01	5,01	4							
	6	79	5,01	5,01	3							
	7	10	5,01	5,01	3	687,42	13,50	0	602,50	16	Hyundai	
	8	40	5,01	5,01	3							
	9	12	5,01	5,01	3							
	10	13	5,01	5,01	3							
	11	20	5,01	5,01	3							
	12	86	5,01	5,01	3							
	13	7	5,01	5,01	3							

Time	Load Count	Loader										
		Loading time				Job Eficiency				Passing	Hauler	Loader type
		Dig time	Swing time		Load time	Working Time	Loss Time					
			Empty	Load			Sorting	Spotting	Waiting			
	14	7	5,01	5,01	3							
	15	4	5,01	5,01	3							
	16	41	5,01	5,01	3							
	17	6	5,01	5,01	3							
	18	7	5,01	5,01	3							
	19	23	5,01	5,01	3							
	20	41	5,01	5,01	3							
	21	23	5,01	5,01	13							
	1				3							
	2	124	5,09	5,09	3							
	3	7	5,09	5,09	3							
	4	10	5,09	5,09	3							
	5	13	5,09	5,09	3							
	6	16	5,09	5,09	3							
	7	10	5,09	5,09	3							
	8	10	5,09	5,09	3							
	9	11	5,09	5,09	3	607,42	0	61,50	0	14	Hyundai	
	10	23	5,09	5,09	3							
	11	13	5,09	5,09	3							
	12	74	5,09	5,09	3							
	13	10	5,09	5,09	3							
	14	12	5,09	5,09	3							
	15	12	5,09	5,09	3							
	16	15	5,09	5,09	3							
	17	24	5,09	5,09	43							

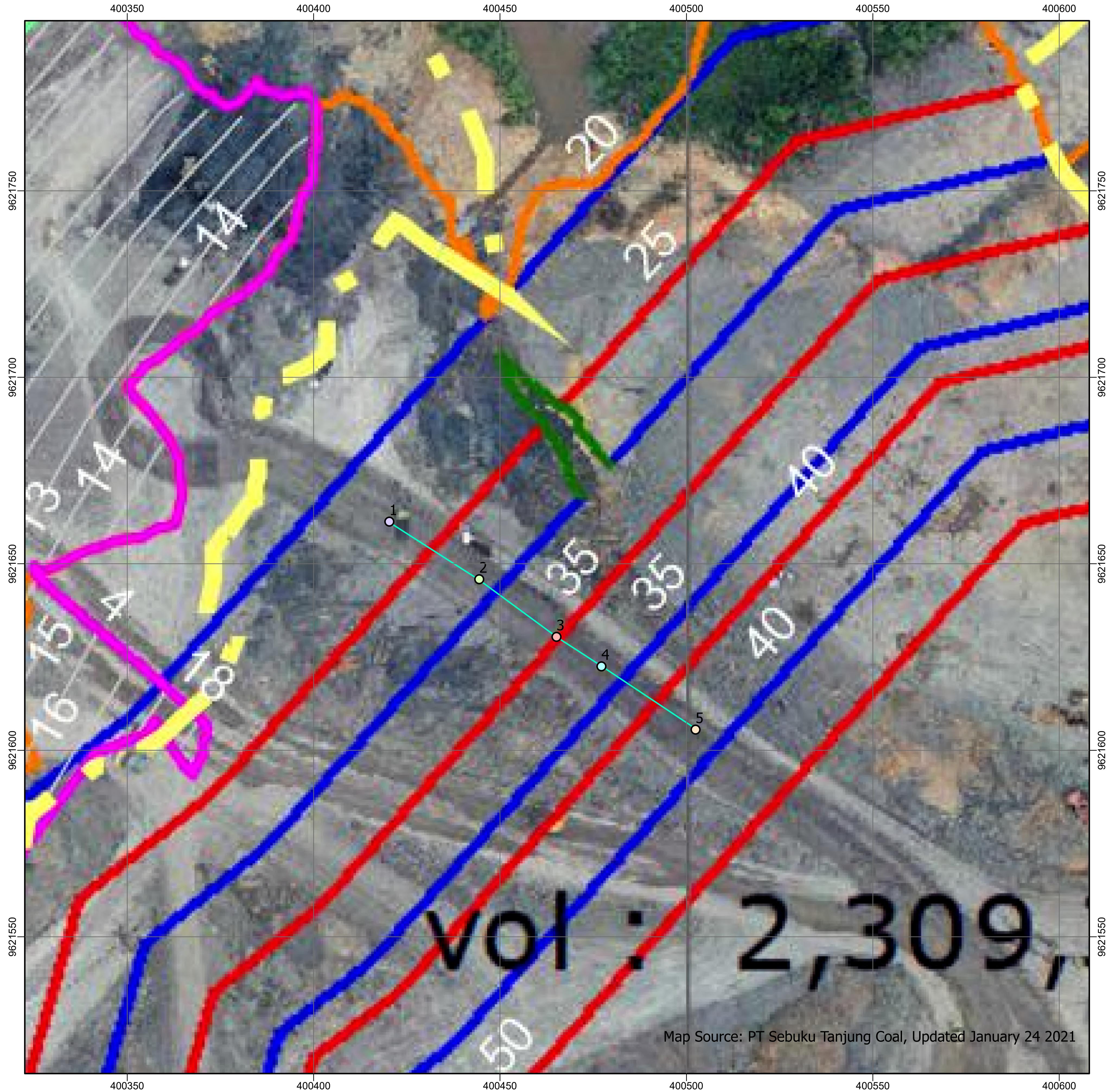
APPENDIX C
HAULER CYCLE TIME

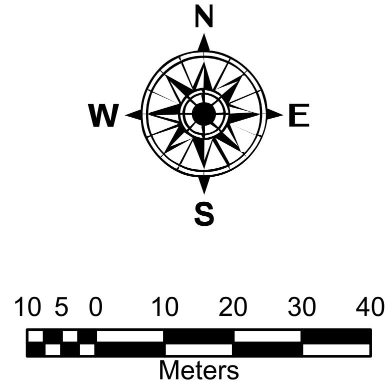
Unit: Second

Date	Type	Haul Time	Spotting to Dumping	Dumping Time	Back Time	Spotting to be Loaded	Total Time/ Rit	Waiting Time		Tracking Time				Total DT	Loading Time
								Port ROM Waiting	Fuel	Front	Pit out	Port	Pit in		
13/1/21	Hyundai	1711	30	78	1706	155	4293	244	142	44	402	568	256	20	415
13/1/21	Hyundai	1595	25	28	1621	70	3596	0	0	105	400	444	243	10	352
21/1/21	Hino	1724	84	34	1463	74	3304	0	0	75	430	457	239	11	322
21/1/21	Hino	1687	44	24	1349	77	3104	0	0	68	348	481	289	11	304
28/1/21	Isuzu	2154	79	92	1725	43	4236	0	187	160	460	549	281	10	328
28/1/21	Isuzu	1867	57	72	1707	44	3702	0	0	260	501	433	270	10	352

APPENDIX D

GRADE MEASUREMENT MAP



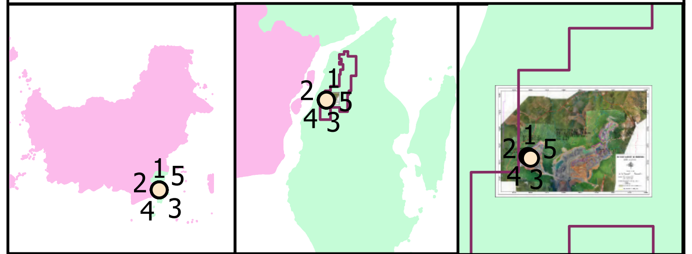


Legend

Grade Point

- 1
- 2
- 3
- 4
- 5
- Grade Line
- Mine Request Level

Cartographic Information
Projection: UTM, Zone 50S
Datum Unit: WGS-84
Sheet Size : A3



MINING ENGINEERING DEPARTMENT
FACULTY OF ENGINEERING
HASANUDDIN UNIVERSITY
2022

THESIS

COAL PRODUCTION FAILURE RISK IDENTIFICATION USING FUZZY FMEA (FAILURE MODE EFFECT ANALYSIS) AT PT SEBUKU TANJUNG COAL SOUTH KALIMANTAN

DRAWN BY	YUBELIUM ANDREW PATILA D111171305
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CO-SUPERVISOR	Dr. ARYANTI VIRTANTI ANAS, S.T., M.T. NIP: 197010052008012026

GRADE MEASUREMENT MAP

APPENDIX	PAGE
D	111

APPENDIX E
FMEA INTERVIEW

Potential Failure Mode	Severity	Occurrence	Detection	RPN
Kurangnya system penyaliran	6	6	3	
Kurangnya jumlah alat *support*	4	6	7	
SR tidak terkontrol	7	6	7	
Grade jalan yang tinggi	7	4	5	
MTTR tinggi	6	6	7	
Desain *cross fall* yang tidak sesuai	4	4	5	
Match factor tidak terkontrol	7	7	5	
Kondisi dan geometri front yang buruk	6	6	5	
Breakdown tak terduga	4	4	5	
Kondisi *haul road* yang buruk	3	4	4	
Presisi rendah pada pengukuran geologi	3	5	4	

Figure E.1 FMEA interview 1

Potential Failure Mode	Severity	Occurrence	Detection	RPN
Lebar *swing* loader yang besar	4.	5	3.	
Kapasitas *heap* yang tidak optimum	3	5	4.	
Jarak hauler jauh dari loader	6	6	6	

Kota Baru ,25 February 2021

Participant,

PARSAULIAN HARIANJA.

Figure E.2 FMEA interview 2

APPENDIX F

DAILY MEETING DOCUMENT

HILLCON **PT. HILLCONJAYA SAKTI**
Job Site STC Pulau Laut - Kotabaru

DAILY PRODUCTION REPORT

DATE : 1-Feb-21
Review : 31-Jan-21

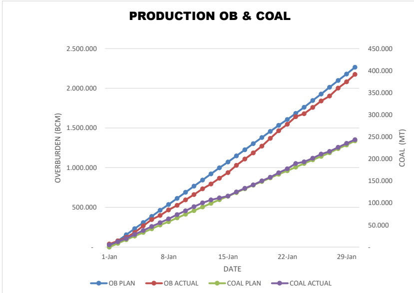
A. REVIEW PRODUCTION

WASTE	PLAN	ACTUAL	
Day To Date (Bcm)	85.550,07	58.662,96	
DTD Achievement		68,57%	
Month To Date (Bcm)	2.350.000,00	2.233.139,29	
MTD Achievement	- 116.860,71	95,03%	
Monthly Plan	2.350.000,00	Ach %	95%

COAL (CO)	PLAN	ACTUAL	
Day To Date (DTD)	9.209,08	6.121,86	
DTD SR	9,29	9,58	
DTD Achievement		66,48%	
Month To Date Coal	250.000,00	249.628,97	
MTD SR	9,40	8,95	
MTD CO Achievement	(371,03)	99,85%	
Monthly Plan	250.000,00	Ach %	100%

PRODUKSI OB	
	TOTAL (Bcm)
Day To Date (Bcm)	7.328
Month To Date (Bcm)	**458.763**
PRODUKSI TOP SOIL	
	TOTAL (Bcm)
Day To Date (Bcm)	1.391
Month To Date (Bcm)	**43.457**
PRODUKSI BLAST	
	TOTAL (Bcm)
Day To Date (Bcm)	47.099
Month To Date (Bcm)	**1.609.240**
COAL	**TONAGE (Mt)**
LOT 1 A1	100.843,54
LOT 2 A1	148.785,43

B. GRAFIK PRODUCTION



YTD Coal 249.628,97

C. LOSS TIME

DISCRIPTION	EST.	ACTUAL
Rain (Hours)	2,40	6,30
MTD	72,00	81,44
Slippery (Hours)	0,72	3,07
MTD	21,60	38,7
Frekuensi Rain		3
Rainfall (mm)		12,50
MTD		262,50
Others (Hours)		

Others Remarks :
Rain (Hours)
10:49-11:00/19:48-22:18/01:18-04:55
Slippery (Hours)
11:00-11:26/22:18-23:35/04:55-06:16

D. COAL EXPOSED & INVENTORY

SEAM	INVENTORY	EXPOSED
A 1		
A 2		
Total		

E. DAILY PLAN 1-Feb-21

OB	79.063	Bcm
COAL	9.036	Ton

E. MINING ACTIVITY

NO	EQUIPMENT	TYPE	UNIT CODE	CONTRACTOR	ACTIVITY	LOCATION	ELEVATION START	ELEVATION TO	DUMPING AREA	DISTANCE (m)	HAULER HD785	HAULER R100E	HAULER SRT95C	HAULER R60D	HAULER ADT	PROD'TY (Bcm/Hr)	REMARKS
Unit OB																	
1	Excavator	PC 2000-8	EXKM21001	Hillcon	OB	PIT T2			OPD T2	542	3					804	Produksi = 9.858 Bcm
2	Excavator	PC 2000-8	EXKM21002	Hillcon	OB	PIT T2			OPD T2	717	4					669	Produksi = 9.657 Bcm
3	Excavator	PC 2000-8	EXKM21003	Hillcon	OB	PIT T1 UTARA			IPD 01	800	4					839	Produksi = 5.945 Bcm
4	Excavator	PC 2000-8	EXKM21004	Hillcon	OB	PIT T1 UTARA			IPD 01	800		3	1			768	Produksi = 9.020 Bcm
5	Excavator	EX1200-7	EXHC12001	Hillcon	OB	PIT T2			OPD T2	663				4		411	Produksi = 5.625 Bcm
6	Excavator	EX1200-7	EXHC12002	Hillcon	OB	PIT T1 UTARA			IPD 01	635	2			1		385	Produksi = 4.916 Bcm
8	Excavator	SY750H	EXSN75001	Hillcon	OB	PIT T2			OPD T2	1.420				3	1	383	Produksi = 4.692 Bcm
9	Excavator	SY500H	EXSN50002	Hillcon	OB	PIT T2			OPD T2	647					3	321	Produksi = 3.365 Bcm
11	Excavator	SY500H	EXSN50004	Hillcon	OB	PIT T1 UTARA			IPD 01	1.019					2	154	Produksi = 1.856 Bcm
12	Excavator	SY500H	EXSN50005	Hillcon	OB	PIT T1 UTARA			IPD 01	1.048					5	321	Produksi = 3.728 Bcm
18	Greader	GD825A-2	MGKM82007	Hillcon	General	ALL PIT											Maintenance Road
19	Greader	GD825A-2	MGKM82008	Hillcon	General	ALL PIT											Maintenance Road
20	Greader	GD705	MGKM70004	Hillcon	General	ALL PIT											Maintenance Road
21	Greader	GD705	MGKM70005	Hillcon	General	ALL PIT											Maintenance Road
23	Bulldozer	D85SS	BDKM85029	Hillcon	General	Disposal IPD 01											Dozing Disposal
24																	
25	Bulldozer	D85SS	BDKM85030	Hillcon	Breakdown	DISPOSAL OPD T2											Dozing Disposal
26	Bulldozer	D155	BDKM15003	Hillcon	General	PIT T1 UTR											Dozing Disposal
27	Bulldozer	D155	BDKM15004	Hillcon	General	PIT T2											Dozing Front Loading
28	Bulldozer	D155	BDKM15006	Hillcon	General	DISPOSAL OPD T2											Dozing Disposal
29	Bulldozer	D375A-6R	BDKM37001	Hillcon	General	DISP IPD 01											Dozing Disposal
30	Bulldozer	822 D	BDSM82001	Hillcon	General	DISP OPD T2											Dozing Disposal
32	Bulldozer	D155	BDKM15010	Hillcon	General	PIT T1 UTARA											Dozing Front Loading
35	Bulldozer	D85SS	BDKM85022	Hillcon	General	PIT T2											Dozing Disposal & Land clearing

NO	EQUIPMENT	TYPE	UNIT CODE	CONTRACTOR	ACTIVITY	LOCATION	ELEVATION START	ELEVATION TO	DUMPING AREA	DISTANCE (m)	DTHY	DTHN	DT GIGA	PROD'TY	REMARKS
Unit Coal															
1	Excavator	SK330-10	EXKB33007	Hillcon	Coal	PIT T2				15.700	4	3	1	126	Produksi = 1.649 Ton
2	Excavator	SY365H	EXSN36003	Hillcon	General & Coal	PIT T2				15.700	3	2	1	135	Produksi = 800 Ton General Stock Coal
3	Excavator	SY365H	EXSN36004	Hillcon	Coal	PIT T1 UTARA				16.100	4	3	2	162	Produksi = 2.059 Ton
10	Excavator	SY500H	EXSN50006	Hillcon	General & Coal	PIT T2				15.700	4	3	2	227	Produksi = 1.613 Ton General Stock Coal
12	Excavator	SY215C	EXSN21005	Hillcon	General	PIT T1 UTARA									Cleaning Coal
13	Excavator	SY215C	EXSN21019	Hillcon	General	PIT T2				-				-	Cleaning Coal &
14	Excavator	SY215C	EXSN21020	Hillcon	General	PIT T2									Cleaning Coal &
15	Excavator	SY215C	EXSN21027	Hillcon	General & Coal	PIT T2				-				-	Produksi = - Ton General
16	Excavator	SK200-10	EXKB20020	Hillcon	General	PIT T1 UTARA									Cleaning Coal

F. BREAKDOWN EQUIPMENT (UNIT PRODUCTION)

NO	EQUIPMENT	TYPE	UNIT CODE	CONTRACTOR	DOWN TIME DATE	EST. RFU	DURATI. (Day)	REMARKS
1	ARTICULATED	A40F	ATVV40025	Hillcon	19-Dec-19			Engine Noise (Waiting Engine)
2	DUMP TRUCK	XCIENT	DTHY38006	Hillcon	17-Nov-19			Brake Rear Jamed & PTO Swap to DT-08, Proppel
3	BULDOZER	D85SS-2A	BDKM85023	Hillcon	17-Feb-20			Top roller worn out
4	DUMP TRUCK	XCIENT	DTHY38008	Hillcon	5-Apr-20			Incident
5	POMPA	CF48	MPMF48001	Hillcon	22-Oct-20			Oil Engine Mix Fuel
6	ARTICULATED	A40F	ATVV40042	Hillcon	9-Nov-20			General Overhoul Engine
7	BULDOZER	D85SS-2A	BDKM85009	Hillcon	8-Oct-20			Oil Transmissi Leak, Engine Noise
8	ARTICULATED	A40F	ATVV40067	Hillcon	23-Nov-20			Parking Brake Can't Release & Engine Noise
9	BULDOZER	D155	BDKM15005	Hillcon	29-Sep-20			T/S Steering Brake
10	BULDOZER	D85SS-2A	BDKM85015	Hillcon	1-Oct-20			Track link loosen
11	ARTICULATED	A40F	ATVV40048	Hillcon	4-Nov-20			General Overhoul Engine
12	DUMP TRUCK	XCIENT	DTHY38021	Hillcon	3-Dec-20			Shock Absorber & Base Assy Front Panel Damage
13	ARTICULATED	A40F	ATVV40064	Hillcon	15-Dec-20			General Overhoul Engine
14	Excavator	ZX470LC-5G	EXHC47001	Hillcon	15-Dec-20			Link H Broken + Low pressure oil E/G
15	DUMP TRUCK	XCIENT	DTHY38012	Hillcon	25-Dec-20			Center Bearing (Waiting Part)
16	Excavator	SY500H	EXSN50003	Hillcon	8-Jan-21			Water Radiator Leak
17	DUMP TRUCK	HINO	DTHN26083	Hillcon	10-Jan-21			Engine Noise
18	DUMP TRUCK	XCIENT	DTHY38014	Hillcon	1-Jan-21			Linning Brake Limit (Waiting Part)
19	ARTICULATED	A40F	ATVV40041	Hillcon	5-Jan-21			Noise saat manuver
20	ARTICULATED	A40F	ATVV40052	Hillcon	14-Jan-21			Engine Suddenly Stop
21	DUMP TRUCK	GIGA	DTIZ34030	Hillcon	20-Jan-21			Schedule Change Vessel
22	ARTICULATED	A40F	ATVV40065	Hillcon	23-Jan-21			Engine Low Power
23	ARTICULATED	A40F	ATVV40057	Hillcon	25-Jan-21			Differential Front Noise
24	EXCAVATOR	EC700BLC	EXVV70004	Hillcon	26-Jan-21			Selenoid Broken

G. WATER MANAGEMENT

LOCATION	WATER VOLUME (m^3) BEFORE	WATER VOLUME (m^3) TODAY		PUMP TYPE	W. Hours	ACT. PUMP CAPACITY (m^3)
PIT T1 BLOK 1				DIESEL 01 PUMP	0,00	-
SUMP 1				Shift I = Shift II =		
SUMP 2				MPMF48001	**0,00**	-
				Shift I = Shift II =		
		Elevasi Air		MPMF48002	**10,98**	3.360
SUMP 1				Shift I = 07:00-11:07 Shift II =21:43-04:35		
SUMP 2				MPMF32001	**13,62**	4.168
				Shift I = 07:00-07:30/09:33-13:23 Shift II = 21:43-07:00		
				MPMF42001	**24,00**	10.368
				Shift I = 07:00-19:00 Shift II = 19:00-07:00		

I. Produksi

	DAILY	MTD	
Disposal OPD 01	**652**	**41.222**	**BCM**
Disposal OPD 02	**-**	**-**	**BCM**
Disposal IPD 01	**25.465**	**1.094.831**	**BCM**
Disposal OPD T2	**32.546**	**1.103.972**	**BCM**

APPENDIX G
FUZZY FMEA CODE

Header

```
"""
Created on Sat Sep 18 15:48:57 2021

@author: Yubelium Andrew Patila
"""
```

Graph Visualization

```
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.patches as mpatches
import skfuzzy as fuzz
from colorama import init
from termcolor import colored
```

Graph

```
def RangeSubject (_Null, _VHigh, _step):
    subject = np.arange(_Null, _VHigh,_step)
    return subject
def AlgorithmFuzzySeverity (_rule,_range_subject,_title):
    Null = fuzz.trimf(_range_subject,_rule[0])
    VLow = fuzz.trimf(_range_subject,_rule[1])
    Low = fuzz.trimf(_range_subject,_rule[2])
    Mod = fuzz.trimf(_range_subject,_rule[3])
    ModHigh = fuzz.trimf(_range_subject,_rule[4])
    High = fuzz.trimf(_range_subject,_rule[5])
    VHigh = fuzz.trimf(_range_subject,_rule[6])

    fig, ax = plt.subplots(nrows = 1, figsize = (8, 4))
    ax.plot (_range_subject, Null,'k', linewidth =1.5, label ='Null')
    ax.plot (_range_subject, VLow,'y', linewidth =1.5, label ='VeryLow')
    ax.plot (_range_subject, Low,'c', linewidth =1.5, label ='Low')
    ax.plot (_range_subject, Mod,'m', linewidth =1.5, label ='Moderate')
```

```
    ax.plot (_range_subject, ModHigh,'g', linewidth =1.5, label ='Moderate-High')
    ax.plot (_range_subject, High,'b', linewidth =1.5, label ='High')
    ax.plot (_range_subject, VHigh,'r', linewidth =1.5, label ='VeryHigh')

    ax.set_title(_title,fontsize=20)
    ax.legend()

    ax.set_xlim([1,10])

    ax.spines['top'].set_visible(False)
    ax.spines['right'].set_visible(False)
    ax.get_xaxis().tick_bottom()
    ax.get_yaxis().tick_left()

    plt.xlabel('Severity', fontsize=14)
    plt.ylabel('Membership Number', fontsize=14)
    plt.tight_layout()
    plt.grid(True)
    plt.legend(bbox_to_anchor=(0., -0.3 , 1., .102),
          ncol=7, mode="expand", borderaxespad=0)
    plt.show()

    return Null, VLow, Low, Mod, ModHigh, High, VHigh

def AlgorithmFuzzyOccurence (_rule,_range_subject,_title):
    Null = fuzz.trimf(_range_subject,_rule[0])
    VLow = fuzz.trimf(_range_subject,_rule[1])
    Low = fuzz.trimf(_range_subject,_rule[2])
    Mod = fuzz.trimf(_range_subject,_rule[3])
    ModHigh = fuzz.trimf(_range_subject,_rule[4])
    High = fuzz.trimf(_range_subject,_rule[5])
    VHigh = fuzz.trimf(_range_subject,_rule[6])

    fig, ax = plt.subplots(nrows = 1, figsize = (8, 4))
```

```
    ax.plot (_range_subject, Null,'k', linewidth =1.5, label ='Null')
    ax.plot (_range_subject, VLow,'y', linewidth =1.5, label ='VeryLow')
    ax.plot (_range_subject, Low,'c', linewidth =1.5, label ='Low')
    ax.plot (_range_subject, Mod,'m', linewidth =1.5, label ='Moderate')
    ax.plot (_range_subject, ModHigh,'g', linewidth =1.5, label ='Moderate-High')
    ax.plot (_range_subject, High,'b', linewidth =1.5, label ='High')
    ax.plot (_range_subject, VHigh,'r', linewidth =1.5, label ='VeryHigh')

    ax.set_title(_title,fontsize=20)
    ax.legend()

    ax.set_xlim([1, 10])

    ax.spines['top'].set_visible(False)
    ax.spines['right'].set_visible(False)
    ax.get_xaxis().tick_bottom()
    ax.get_yaxis().tick_left()

    plt.xlabel('Occurrence', fontsize=14)
    plt.ylabel('Membership Number', fontsize=14)
    plt.tight_layout()
    plt.grid(True)
    plt.legend(bbox_to_anchor=(0., -0.3 , 1., .102),
           ncol=7, mode="expand", borderaxespad=0)
    plt.show()

    return Null, VLow, Low, Mod, ModHigh, High, VHigh

def AlgorithmFuzzyDetection (_rule,_range_subject,_title):
    Null = fuzz.trimf(_range_subject,_rule[0])
    VLow = fuzz.trimf(_range_subject,_rule[1])
    Low = fuzz.trimf(_range_subject,_rule[2])
    Mod = fuzz.trimf(_range_subject,_rule[3])
    ModHigh = fuzz.trimf(_range_subject,_rule[4])
```

```
    High = fuzz.trimf(_range_subject,_rule[5])
    VHigh = fuzz.trimf(_range_subject,_rule[6])

    fig, ax = plt.subplots(nrows = 1, figsize = (8, 4))
    ax.plot (_range_subject, Null,'k', linewidth =1.5, label ='Null')
    ax.plot (_range_subject, VLow,'y', linewidth =1.5, label ='VeryLow')
    ax.plot (_range_subject, Low,'c', linewidth =1.5, label ='Low')
    ax.plot (_range_subject, Mod,'m', linewidth =1.5, label ='Moderate')
    ax.plot (_range_subject, ModHigh,'g', linewidth =1.5, label ='Moderate-High')
    ax.plot (_range_subject, High,'b', linewidth =1.5, label ='High')
    ax.plot (_range_subject, VHigh,'r', linewidth =1.5, label ='VeryHigh')

    ax.set_title(_title,fontsize=20)
    ax.legend()

    ax.set_xlim([1,10])

    ax.spines['top'].set_visible(False)
    ax.spines['right'].set_visible(False)
    ax.get_xaxis().tick_bottom()
    ax.get_yaxis().tick_left()

    plt.xlabel('Detection', fontsize=14)
    plt.ylabel('Membership Number', fontsize=14)
    plt.tight_layout()
    plt.grid(True)
    plt.legend(bbox_to_anchor=(0., -0.3 , 1., .102),
           ncol=7, mode="expand", borderaxespad=0)
    plt.show()

    return Null, VLow, Low, Mod, ModHigh, High, VHigh

def RangeFRPN (_NIm,_VIm,_step):
    subject = np.arange (_NIm,_VIm,_step)
```

```
    return subject
def FRPNGraph (_rule,_range_subject,_title):
    NIm = fuzz.trapmf(_range_subject,_rule[0])
    Min = fuzz.trapmf(_range_subject,_rule[1])
    Mod = fuzz.trapmf(_range_subject,_rule[2])
    Im = fuzz.trapmf(_range_subject,_rule[3])
    VIm = fuzz.trapmf(_range_subject,_rule[4])

    fig, ax = plt.subplots(nrows = 1, figsize = (8, 4))
    ax.plot (_range_subject, NIm,'k', linewidth =1.5, label ='Not Important')
    ax.plot (_range_subject, Min,'y', linewidth =1.5, label ='Minor')
    ax.plot (_range_subject, Mod,'c', linewidth =1.5, label ='Moderate')
    ax.plot (_range_subject, Im,'m', linewidth =1.5, label ='Important')
    ax.plot (_range_subject, VIm,'g', linewidth =1.5, label ='Very Important')

    ax.set_title(_title,fontsize=20)
    ax.legend()

    ax.set_xlim([1,1000])

    ax.spines['top'].set_visible(False)
    ax.spines['right'].set_visible(False)
    ax.get_xaxis().tick_bottom()
    ax.get_yaxis().tick_left()

    plt.xlabel('FRPN', fontsize=14)
    plt.ylabel('Membership Number', fontsize=14)
    plt.tight_layout()
    plt.grid(True)
    plt.legend(bbox_to_anchor=(0., -0.3 , 1., .102),
           ncol=5, mode="expand", borderaxespad=0)
    plt.show()

    return NIm, Min, Mod, Im, VIm
```

```
#%%
# Graph array
xFuzRuleS = RangeSubject (1, 11, 0.5)
rFuzRuleS = np.array([
    [1, 1, 2.5],
    [1, 2.5, 4],
    [2.5, 4, 5.5],
    [4, 5.5, 7],
    [5.5, 7, 8.5],
    [7, 8.5, 10],
    [8.5, 10, 10],
])
Null_FuzRuleS, VLow_FuzRuleS, Low_FuzRuleS, Mod_FuzRuleS, ModHigh_FuzRuleS,
High_FuzRuleS, VHigh_FuzRuleS = AlgorithmFuzzySeverity(rFuzRuleS, xFuzRuleS,
'Severity Index')

xFuzRuleO = RangeSubject (1, 11, 0.5)
rFuzRuleO = np.array([
    [1, 1, 2.5],
    [1, 2.5, 4],
    [2.5, 4, 5.5],
    [4, 5.5, 7],
    [5.5, 7, 8.5],
    [7, 8.5, 10],
    [8.5, 10, 10],
])
Null_FuzRuleO, VLow_FuzRuleO, Low_FuzRuleO, Mod_FuzRuleO, ModHigh_FuzRuleO,
High_FuzRuleO, VHigh_FuzRuleO = AlgorithmFuzzyOccurence(rFuzRuleO, xFuzRuleO,
'Occurrence Index')

xFuzRuleD = RangeSubject (1, 11, 0.5)
rFuzRuleD = np.array([
    [1, 1, 2.5],
```

```
    [1, 2.5, 4],
    [2.5, 4, 5.5],
    [4, 5.5, 7],
    [5.5, 7, 8.5],
    [7, 8.5, 10],
    [8.5, 10, 10],
])
Null_FuzRuleD, VLow_FuzRuleD, Low_FuzRuleD, Mod_FuzRuleD, ModHigh_FuzRuleD,
High_FuzRuleD, VHigh_FuzRuleD = AlgorithmFuzzyDetection(rFuzRuleD, xFuzRuleD,
'Detection Index')
xFRPN = RangeFRPN (1, 1001, 1)
rFRPN = np.array([
    [0, 0, 100, 200],
    [100, 200, 300, 400],
    [300, 400, 600, 700],
    [600, 700, 800, 900],
    [800, 900, 1000, 1000],
])
NIm_FRPN, Min_FRPN, Mod_FRPN, Im_FRPN, VIm_FRPN = FRPNGraph(rFRPN, xFRPN,
'FRPN')
```

Fuzzy input

```
I_severity = input('Severity Value : ')
I_occurence = input('Occurrence Value : ')
I_detection = input('Detection Value : ')

severity = int(I_severity)
occurence = int(I_occurence)
detection = int(I_detection)
I_FRPN = severity*occurence*detection
FRPN = int(I_FRPN)
print('FRPN = ', FRPN)
```

Fuzzyfication

Defined membership

```
NullS = np.array(fuzz.interp_membership(xFuzRuleS,Null_FuzRuleS,severity))
VLowS = np.array(fuzz.interp_membership(xFuzRuleS,VLow_FuzRuleS,severity))
LowS = np.array(fuzz.interp_membership(xFuzRuleS,Low_FuzRuleS,severity))
ModS = np.array(fuzz.interp_membership(xFuzRuleS,Mod_FuzRuleS,severity))
ModHighS = np.array(fuzz.interp_membership(xFuzRuleS,ModHigh_FuzRuleS,severity))
HighS = np.array(fuzz.interp_membership(xFuzRuleS,High_FuzRuleS,severity))
VHighS = np.array(fuzz.interp_membership(xFuzRuleS,VHigh_FuzRuleS,severity))
print("")
print ('SEVERITY MEMBERSHIP')
print ('Null = ', NullS)
print ('Very Low = ', VLowS)
print ('Low = ', LowS)
print ('Moderate = ', ModS)
print ('Moderate High = ', ModHighS)
print ('High = ', HighS)
print ('Very High = ', VHighS)

NullO = np.array(fuzz.interp_membership(xFuzRuleO,Null_FuzRuleO,occurence))
VLowO = np.array(fuzz.interp_membership(xFuzRuleO,VLow_FuzRuleO,occurence))
LowO = np.array(fuzz.interp_membership(xFuzRuleO,Low_FuzRuleO,occurence))
ModO = np.array(fuzz.interp_membership(xFuzRuleO,Mod_FuzRuleO,occurence))
ModHighO =
np.array(fuzz.interp_membership(xFuzRuleO,ModHigh_FuzRuleO,occurence))
HighO = np.array(fuzz.interp_membership(xFuzRuleO,High_FuzRuleO,occurence))
VHighO = np.array(fuzz.interp_membership(xFuzRuleO,VHigh_FuzRuleO,occurence))
print("")
print ('OCCURENCE MEMBERSHIP')
print ('Null = ', NullO)
print ('Very Low = ', VLowO)
print ('Low = ', LowO)
```

```
print ('Moderate = ', ModO)
print ('Moderate High = ', ModHighO)
print ('High = ', HighO)
print ('Very High = ', VHighO)


NullD = np.array(fuzz.interp_membership(xFuzRuleD,Null_FuzRuleD,detection))
VLowD = np.array(fuzz.interp_membership(xFuzRuleD,VLow_FuzRuleD,detection))
LowD = np.array(fuzz.interp_membership(xFuzRuleD,Low_FuzRuleD,detection))
ModD = np.array(fuzz.interp_membership(xFuzRuleD,Mod_FuzRuleD,detection))
ModHighD =
np.array(fuzz.interp_membership(xFuzRuleD,ModHigh_FuzRuleD,detection))
HighD = np.array(fuzz.interp_membership(xFuzRuleD,High_FuzRuleD,detection))
VHighD = np.array(fuzz.interp_membership(xFuzRuleD,VHigh_FuzRuleD,detection))
print("")
print ('DETECTION MEMBERSHIP')
print ('Null = ', NullD)
print ('Very Low = ', VLowD)
print ('Low = ', LowD)
print ('Moderate = ', ModD)
print ('Moderate High = ', ModHighD)
print ('High = ', HighD)
print ('Very High = ', VHighD)


NImFRPN = np.array(fuzz.interp_membership(xFRPN,NIm_FRPN,FRPN))
MinFRPN = np.array(fuzz.interp_membership(xFRPN,Min_FRPN,FRPN))
ModFRPN = np.array(fuzz.interp_membership(xFRPN,Mod_FRPN,FRPN))
ImFRPN = np.array(fuzz.interp_membership(xFRPN,Im_FRPN,FRPN))
VImFRPN = np.array(fuzz.interp_membership(xFRPN,VIm_FRPN,FRPN))
print("")
print ('FRPN MEMBERSHIP')
print ('Not Important = ', NImFRPN)
print ('Minimum = ', MinFRPN)
```

```
print ('Moderate = ', ModFRPN)
print ('Important = ', ImFRPN)
print ('Very Important = ', VImFRPN)
```

Rule Base

Agregation and Activation

```
RuleBase1 = np.fmin(HighS,HighO,HighD )
FRPN_Activation1 = np.fmin(RuleBase1, VIm_FRPN)

RuleBase2 = np.fmin( VLowS, VLowO, LowD )
FRPN_Activation2 = np.fmin(RuleBase2, Min_FRPN)

RuleBase3 = np.fmin( ModS, ModHighO, VLowD )
FRPN_Activation3 = np.fmin(RuleBase3, Mod_FRPN)

RuleBase4 = np.fmin( ModS, ModO, ModD )
FRPN_Activation4 = np.fmin(RuleBase4, Im_FRPN)

RuleBase5 = np.fmin( LowS, VLowO, VHighD )
FRPN_Activation5 = np.fmin(RuleBase5, Mod_FRPN)

RuleBase6 = np.fmin( VLowS, LowO, ModD )
FRPN_Activation6 = np.fmin(RuleBase6, Min_FRPN)

RuleBase7 = np.fmin( VLowS, VLowO, VLowD )
FRPN_Activation7 = np.fmin(RuleBase7, NIm_FRPN)

RuleBase8 = np.fmin( VLowS, LowO, ModD )
FRPN_Activation8 = np.fmin(RuleBase8, Mod_FRPN)

RuleBase9 = np.fmin( HighS, ModO, ModD )
FRPN_Activation9 = np.fmin(RuleBase9, VIm_FRPN)

RuleBase10 = np.fmin( ModS, VLowO, VLowD )
```

```
FRPN_Activation10 = np.fmin(RuleBase10, Im_FRPN)

RuleBase11 = np.fmin( ModS, ModHighO, VLowD )
FRPN_Activation11 = np.fmin(RuleBase11, Im_FRPN)

RuleBase12 = np.fmin( ModS, ModHighO, LowD )
FRPN_Activation12 = np.fmin(RuleBase12, Mod_FRPN)

RuleBase13 = np.fmin( HighS, HighO, ModD )
FRPN_Activation13 = np.fmin(RuleBase13, VIm_FRPN)

RuleBase14 = np.fmin( VLowS, ModO, VLowD )
FRPN_Activation14 = np.fmin(RuleBase14, Mod_FRPN)

FRPN_Zero = np.zeros_like(xFRPN)
```

Accumulation Graph

```
fig, ax0 = plt.subplots(figsize=(8, 4))
ax0.plot (xFRPN, NIm_FRPN,'k', linewidth =0.5)
ax0.plot (xFRPN, Min_FRPN,'y', linewidth =0.5)
ax0.plot (xFRPN, Mod_FRPN,'c', linewidth =0.5)
ax0.plot (xFRPN, Im_FRPN,'m', linewidth =0.5)
ax0.plot (xFRPN, VIm_FRPN,'g', linewidth =0.5)

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation1, facecolor='k', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation1, 'k', linewidth=0.5)
patch1 = mpatches.Patch(color='k', label='Rule 1')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation2, facecolor='y', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation2, 'y', linewidth=0.5)
patch2 = mpatches.Patch(color='y', label='Rule 2')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation3, facecolor='c', alpha=0.7)
```

```
ax0.plot(xFRPN, FRPN_Activation3, 'c', linewidth=0.5)
patch3 = mpatches.Patch(color='c', label='Rule 3')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation4, facecolor='m', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation4, 'm', linewidth=0.5)
patch4 = mpatches.Patch(color='m', label='Rule 4')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation5, facecolor='g', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation5, 'g', linewidth=0.5 )
patch5 = mpatches.Patch(color='g', label='Rule 5')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation6, facecolor='r', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation6, 'r', linewidth=0.5)
patch6 = mpatches.Patch(color='r', label='Rule 6')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation7, facecolor='tan', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation7, 'tan', linewidth=0.5)
patch7 = mpatches.Patch(color='tan', label='Rule 7')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation8, facecolor='khaki', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation8, 'khaki', linewidth=0.5)
patch8 = mpatches.Patch(color='khaki', label='Rule 8')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation9, facecolor='indigo', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation9, 'indigo', linewidth=0.5)
patch9 = mpatches.Patch(color='indigo', label='Rule 9')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation10, facecolor='slategray',
alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation10, 'slategray', linewidth=0.5)
patch10 = mpatches.Patch(color='slategray', label='Rule 10')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation11, facecolor='gold', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation11, 'gold', linewidth=0.5)
```

```
patch11 = mpatches.Patch(color='gold', label='Rule 11')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation12, facecolor='azure', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation12, 'slateblue', linewidth=0.5)
patch12 = mpatches.Patch(color='slateblue', label='Rule 12')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation13, facecolor='pink', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation13, 'pink', linewidth=0.5)
patch13 = mpatches.Patch(color='pink', label='Rule 13')

ax0.fill_between(xFRPN, FRPN_Zero, FRPN_Activation14, facecolor='lime', alpha=0.7)
ax0.plot(xFRPN, FRPN_Activation14, 'lime', linewidth=0.5)
patch14 = mpatches.Patch(color='lime', label='Rule 14')

ax0.set_title('Output membership activity')



for ax in (ax0,):
    ax.spines['top'].set_visible(False)
    ax.spines['right'].set_visible(False)
    ax.get_xaxis().tick_bottom()
    ax.get_yaxis().tick_left()
    ax.set_xlim([1,1000])
    ax.legend()

plt.legend(bbox_to_anchor=(0., -0.25 , 1., .102),
           ncol=7, mode="expand", borderaxespad=0, handles=[patch1,patch2,
                                                 patch3,patch4,
                                                 patch5,patch6,
                                                 patch7,patch8,
                                                 patch9,patch10,
                                                 patch11,patch12,
                                                 patch13,patch14])
plt.tight_layout()
```

plt.show()

Agregate

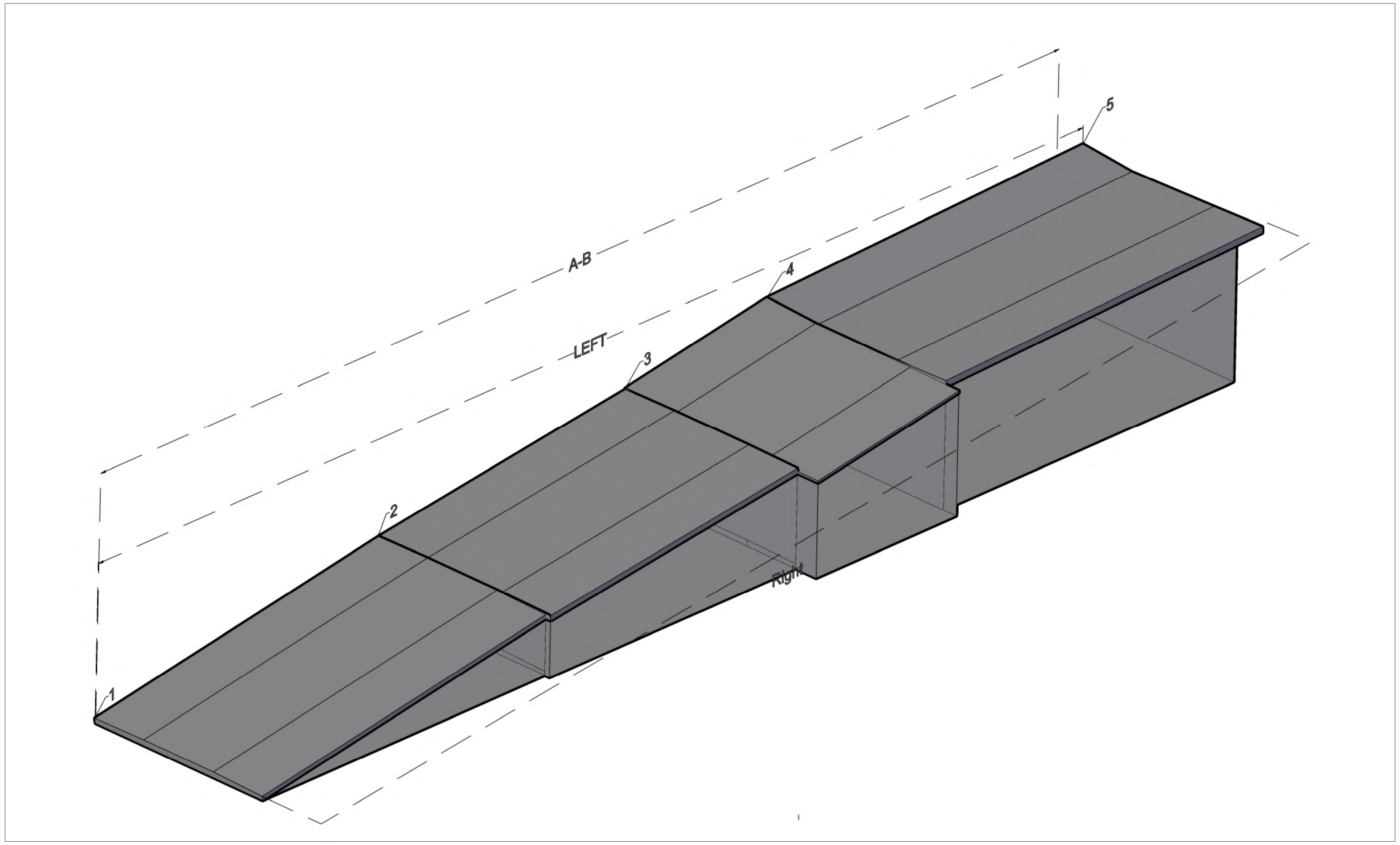
```
FRPN_agregate = np.fmax (FRPN_Activation1,
                    np.fmax(FRPN_Activation2,
                        np.fmax(FRPN_Activation3,
                            np.fmax(FRPN_Activation4,
                                np.fmax(FRPN_Activation5,
                                    np.fmax(FRPN_Activation6,
                                        np.fmax(FRPN_Activation7,
                                            np.fmax(FRPN_Activation8,

np.fmax(FRPN_Activation9,

np.fmax(FRPN_Activation10,

np.fmax(FRPN_Activation11,

np.fmax(FRPN_Activation12,

np.fmax(FRPN_Activation13,FRPN_Activation14)))))))))))))

#%%
# Defuuzification
FRPN_Output = fuzz.defuzz(xFRPN, FRPN_agregate, 'centroid')
FRPN_Activation = fuzz.interp_membership(xFRPN, FRPN_agregate, FRPN)

fig, ax = plt.subplots(nrows = 1, figsize = (8, 4))
ax.plot([FRPN, FRPN], [0, FRPN_Activation], 'k', linewidth=1.5, alpha=0.9)
ax.plot (xFRPN, NIm_FRPN,'k', linewidth =0.5, label ='Not Important')
ax.plot (xFRPN, Min_FRPN,'y', linewidth =0.5, label ='Minor')
ax.plot (xFRPN, Mod_FRPN,'c', linewidth =0.5, label ='Moderate')
ax.plot (xFRPN, Im_FRPN,'m', linewidth =0.5, label ='Important')
```

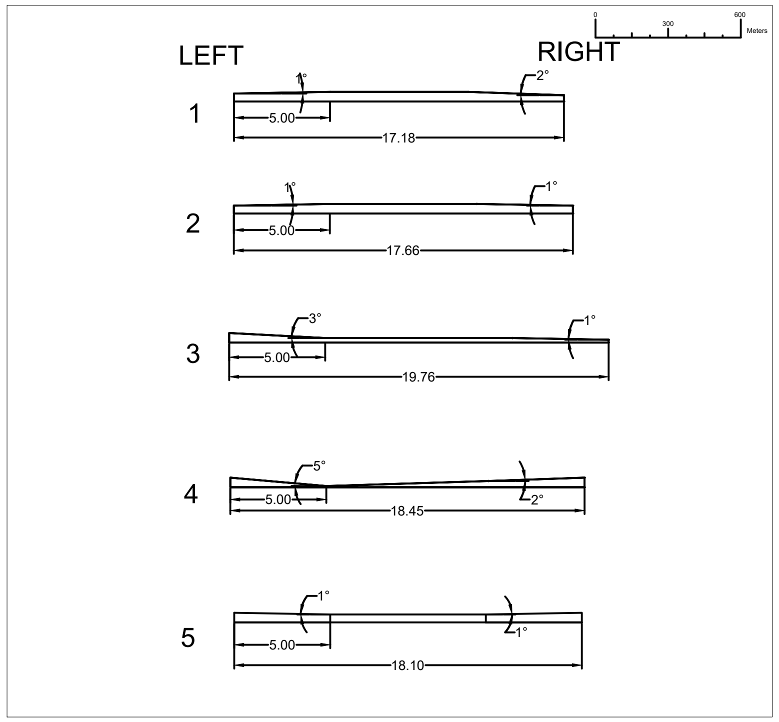
```
ax.plot (xFRPN, VIm_FRPN,'g', linewidth =0.5, label ='Very Important')
ax.fill_between(xFRPN, FRPN_Zero, FRPN_agregate, facecolor='Orange', alpha=0.7)
ax.set_title('Aggregated membership and result (line)', fontsize=20)
patchagregated = mpatches.Patch(color='Orange', label='Agregated area')

ax.legend()

ax.set_xlim([1,1000])

ax.spines['top'].set_visible(False)
ax.spines['right'].set_visible(False)
ax.get_xaxis().tick_bottom()
ax.get_yaxis().tick_left()

plt.xlabel('FRPN', fontsize=14)
plt.ylabel('Membership Number', fontsize=14)
plt.tight_layout()
plt.grid(False)
plt.legend(bbox_to_anchor=(0., -0.25 , 1., .102), borderaxespad=0,
handles=[patchagregated])
plt.show()

print("")
print ('Final FRPN')
print ('FRPN = ',round( int(float(str (FRPN_Output)))))

init()
if int(float(str (FRPN_Output))) >= 1 and int(float(str (FRPN_Output))) < 200 :
   print ("FRPN Class:", colored('Not Important.', 'green'))
elif int(float(str (FRPN_Output))) >= 200 and int(float(str (FRPN_Output))) < 400 :
   print ("FRPN Class:", colored('Minor.', 'cyan'))
elif int(float(str (FRPN_Output))) >= 400 and int(float(str (FRPN_Output))) < 600 :
   print ("FRPN Class:", colored('Moderate.', 'blue'))
elif int(float(str (FRPN_Output))) >= 600 and int(float(str (FRPN_Output))) < 800 :
```

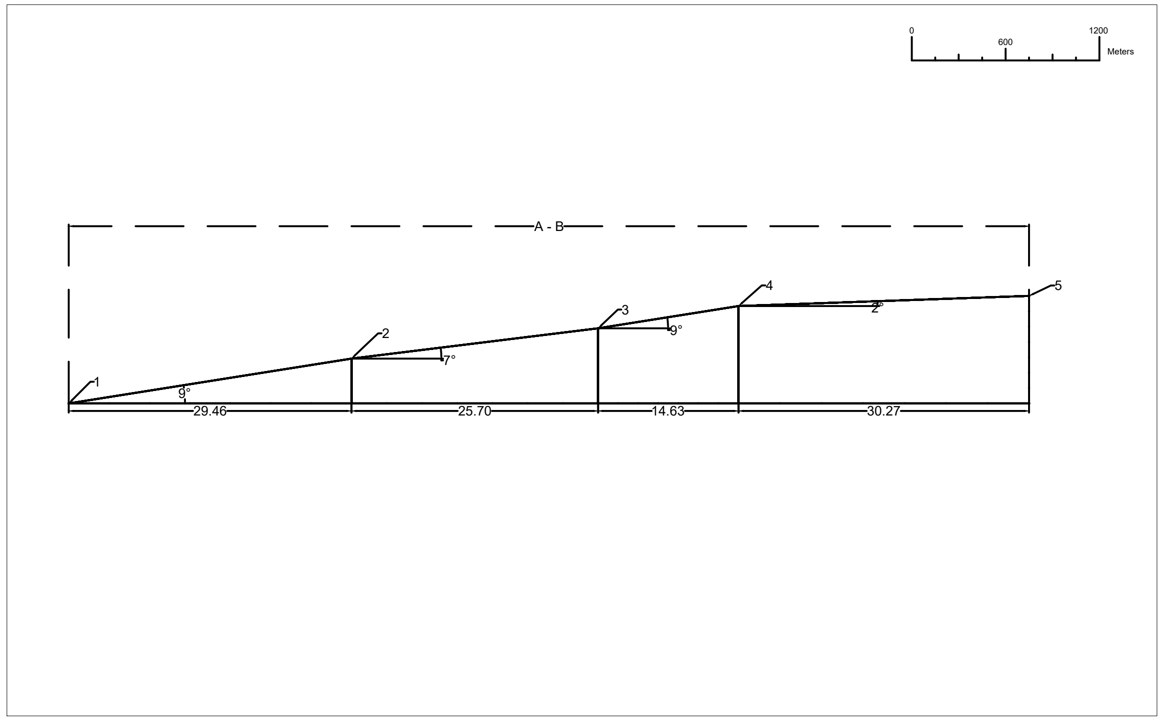
```
    print ("FRPN Class:", colored('Important.', 'yellow'))
else:
    print ("FRPN Class:" , colored('Very Important.', 'red'))
```

APPENDIX H

ROAD GRADE AND CROSS FALL MODEL







0 300 600 Meters

Legend

Projection Line

Point arrow

Angle Arrow

Dimension arrow

Unit : Meter

Sheet size : A3

MINING ENGINEERING DEPARTMENT
FACULTY OF ENGINEERING
HASANUDDIN UNIVERSITY
2022

THESIS

COAL PRODUCTION FAILURE RISK IDENTIFICATION USING FUZZY FMEA (FAILURE MODE EFFECT ANALYSIS) AT PT SEBUKU TANJUNG COAL SOUTH KALIMANTAN

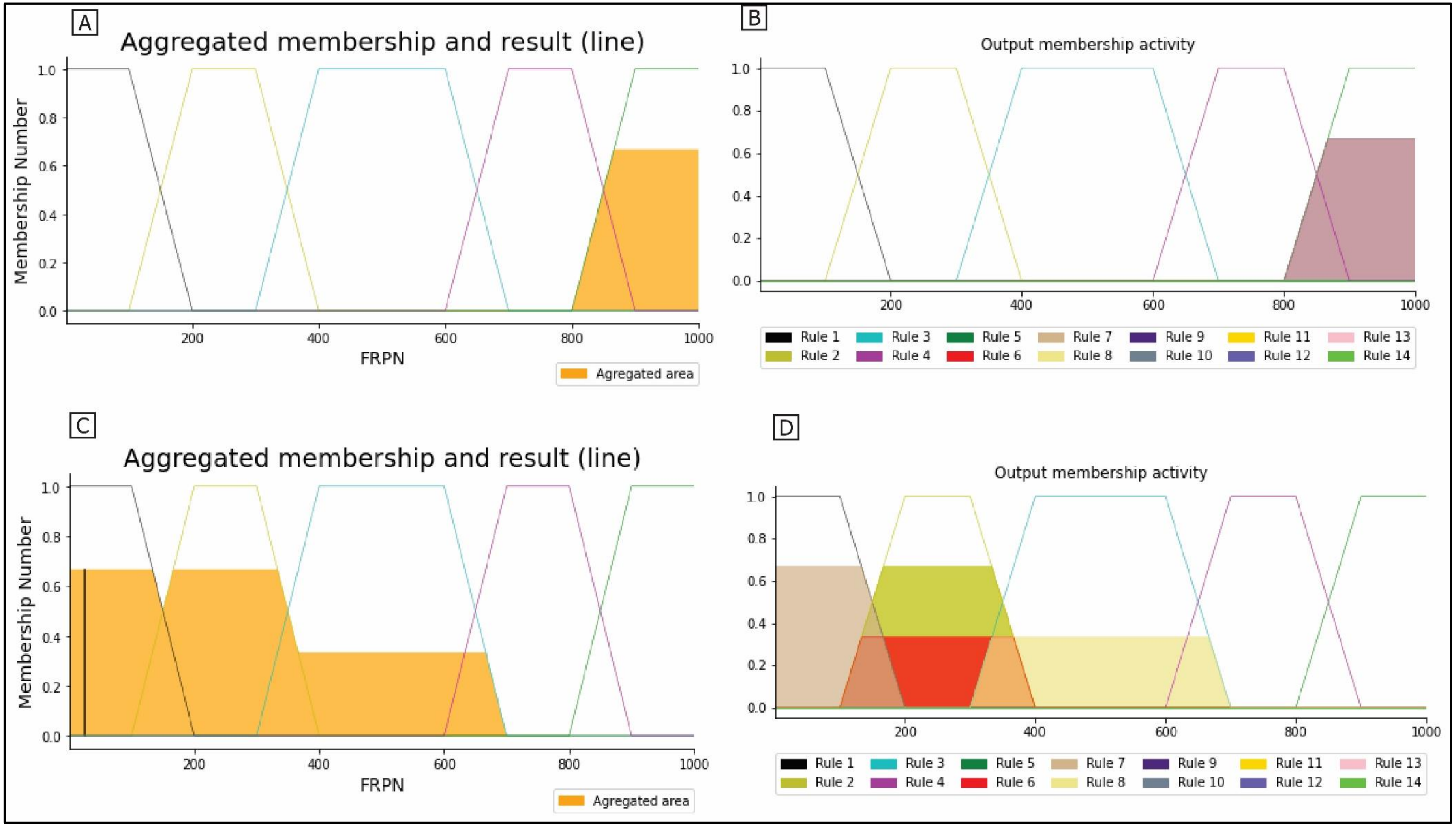
EDITED BY	YUBELIUM ANDREW PATILA D111171305
MAIN SUPERVISOR	Dr. Eng. RINI NOVRIANTI SUTARDJO TUI, M.T., M.BA. NIP: 198311142014042001
CO-SUPERVISOR	Dr. ARYANTI VIRTANTI ANAS, S.T., M.T. NIP: 197010052008012026

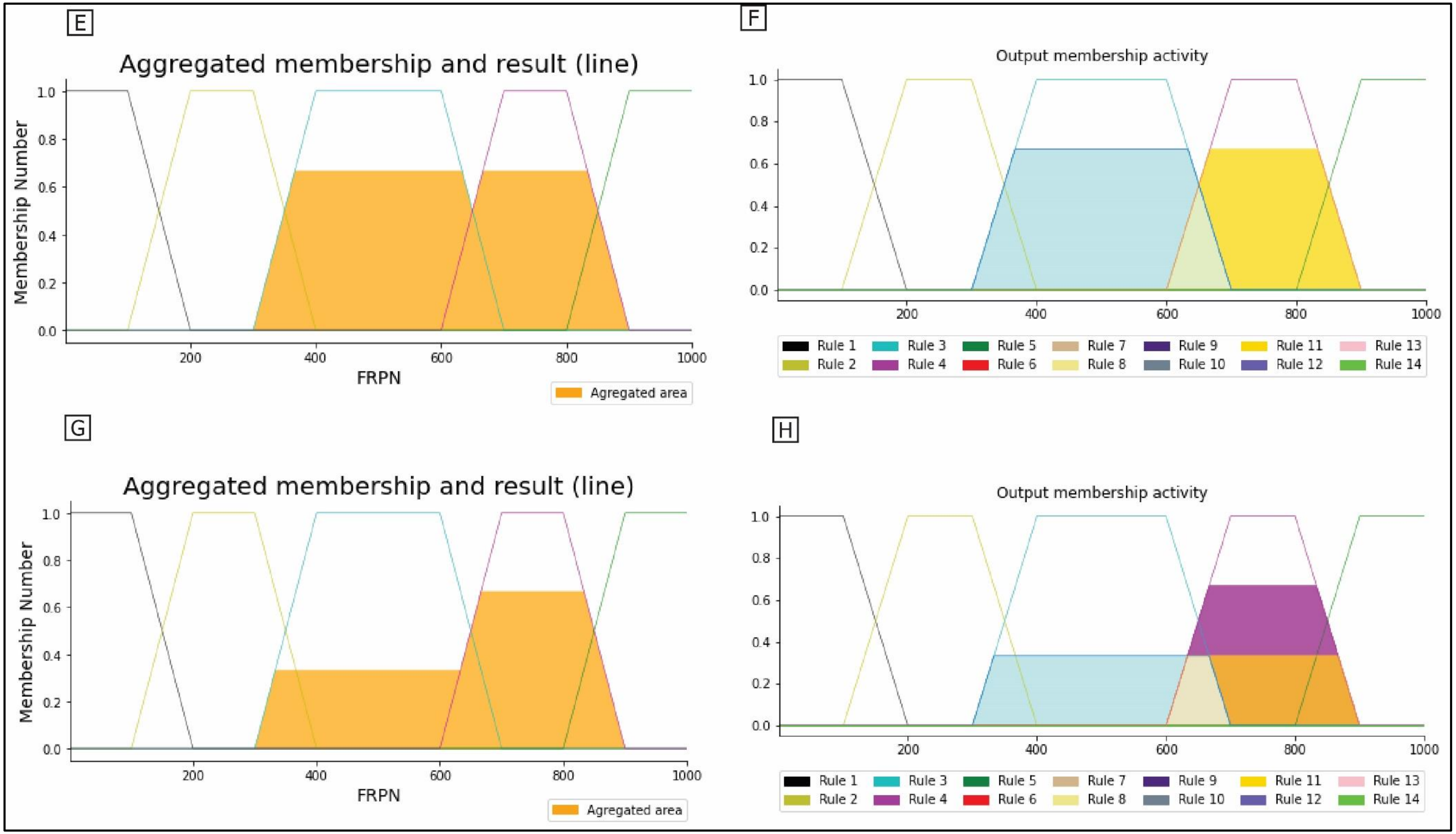
ROAD GRADE AND CROSS FALL MODEL

APPENDIX	PAGE
H	134

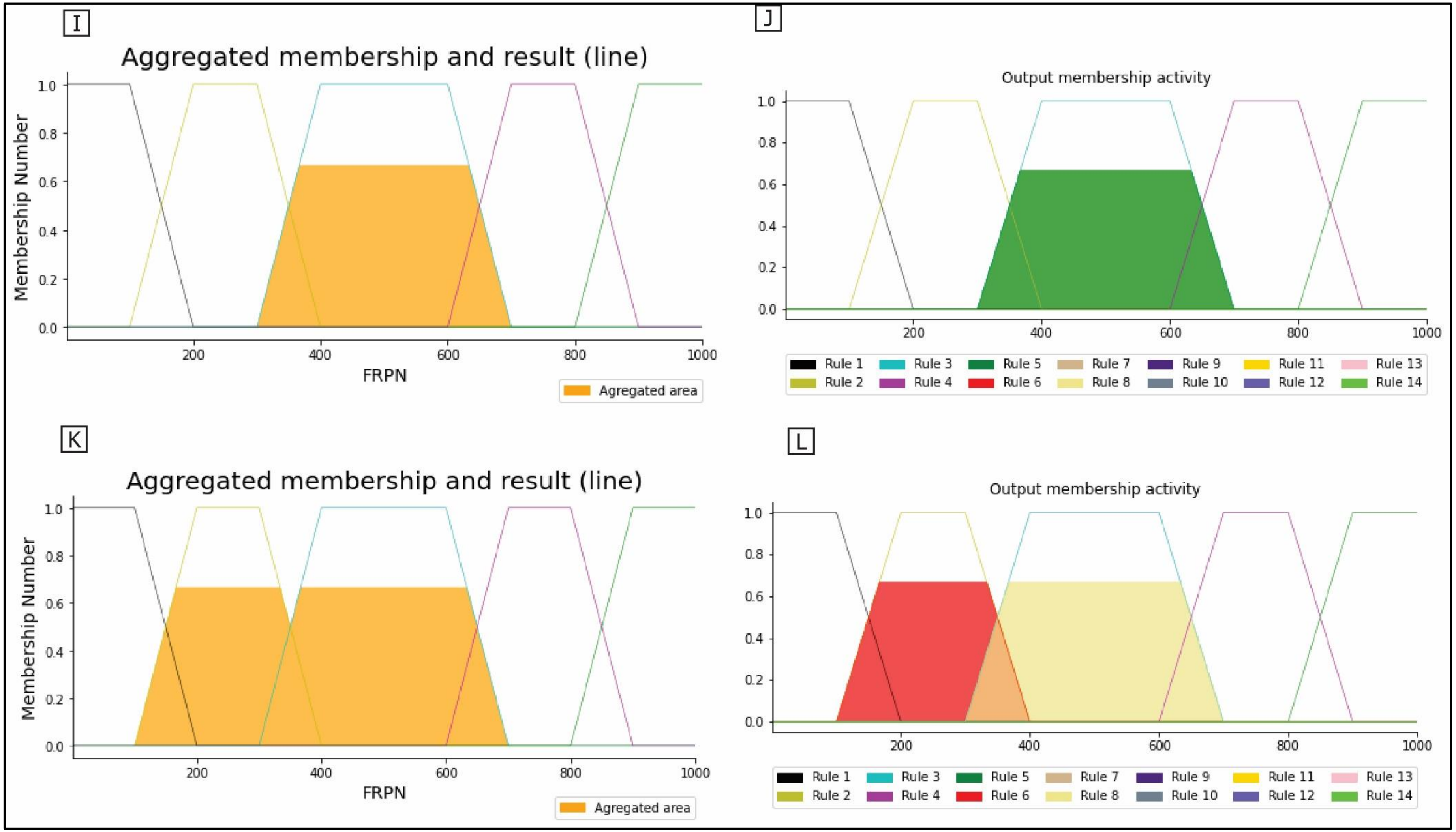
APPENDIX I

FAILURE MODE AGREGATION

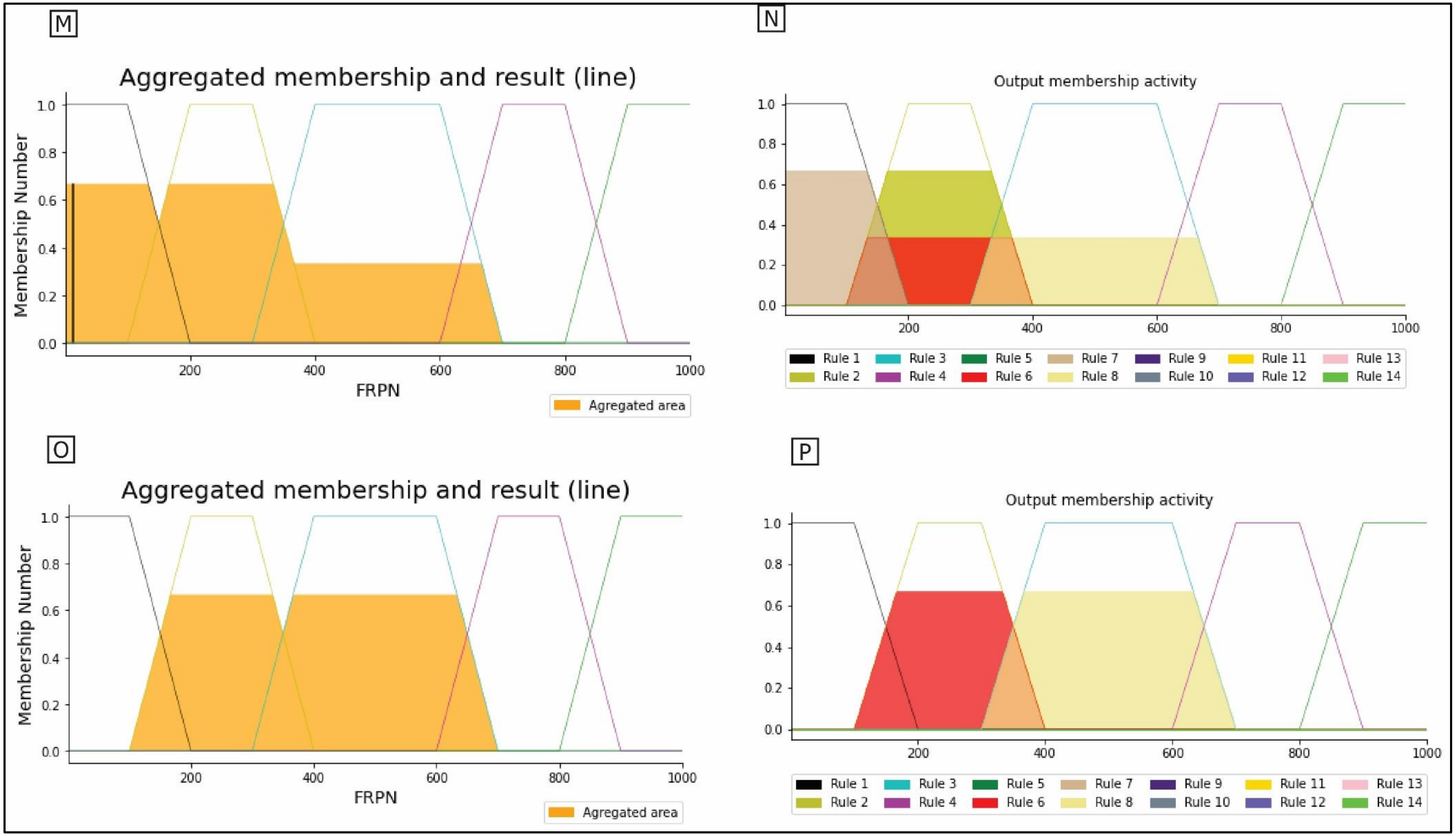

A
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
B
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14
C
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
D
Output membership activity

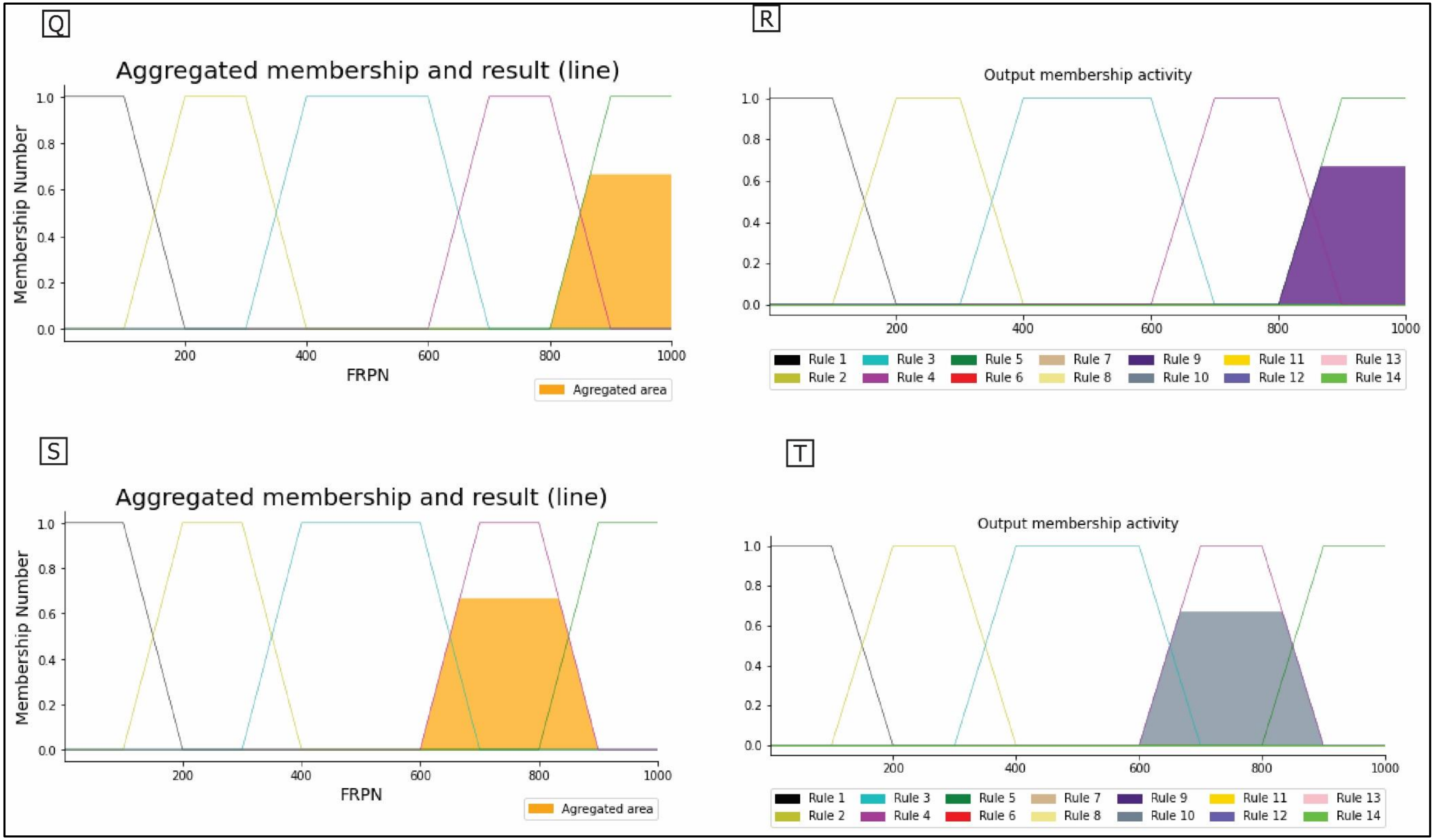


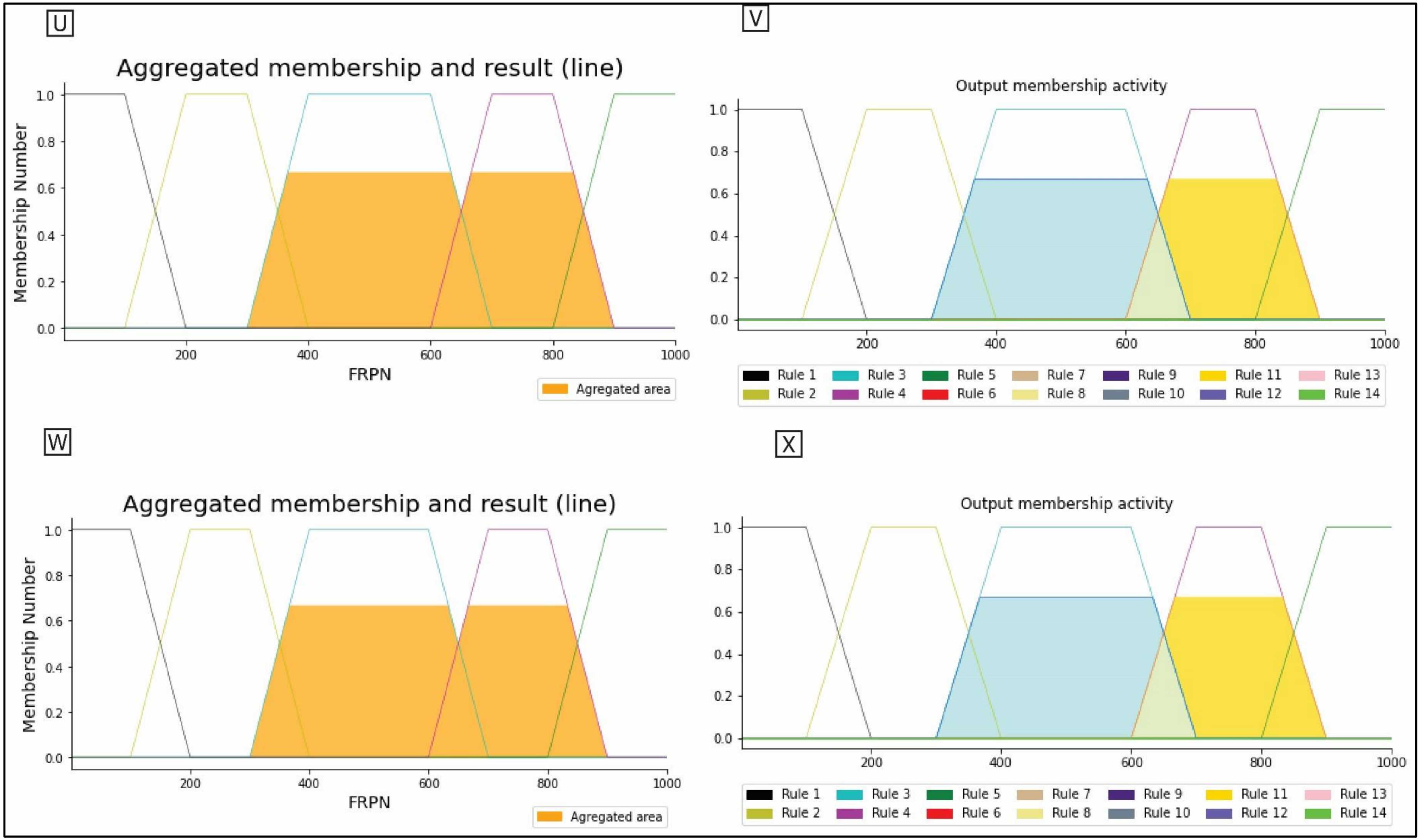
E
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
F
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14
G
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
H
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14



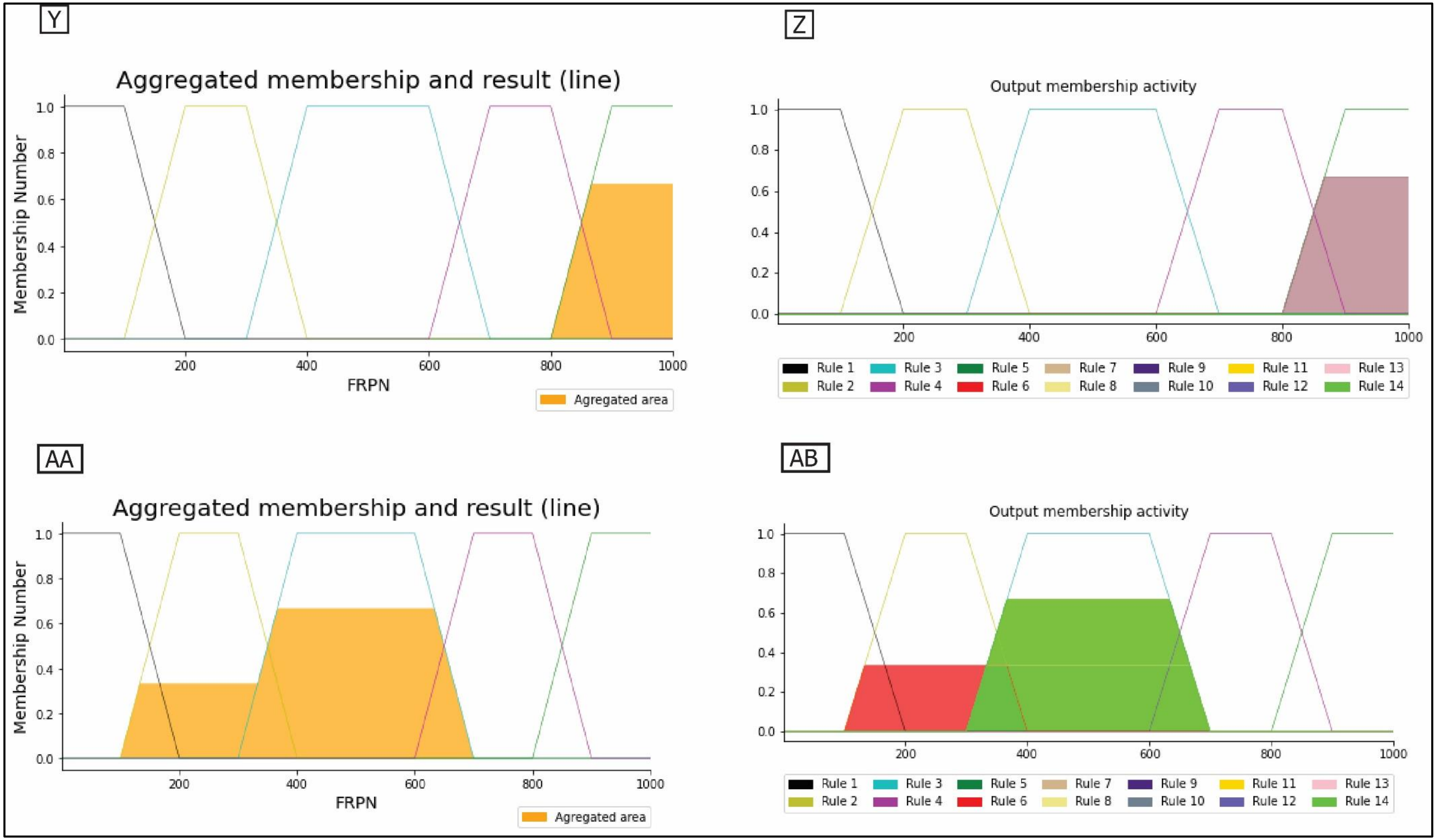
I
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
J
Output membership activity
Rule 1 Rule 2 Rule 3 Rule 4 Rule 5 Rule 6 Rule 7 Rule 8 Rule 9 Rule 10 Rule 11 Rule 12 Rule 13 Rule 14
K
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
L
Output membership activity
Rule 1 Rule 2 Rule 3 Rule 4 Rule 5 Rule 6 Rule 7 Rule 8 Rule 9 Rule 10 Rule 11 Rule 12 Rule 13 Rule 14


M
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
N
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14
O
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
P
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14


Q
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
R
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14
S
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
T
Output membership activity



U
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
V
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14
W
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
X
Output membership activity


Y
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
Z
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14
AA
Aggregated membership and result (line)
Membership Number
FRPN
Agregated area
AB
Output membership activity
Rule 1
Rule 2
Rule 3
Rule 4
Rule 5
Rule 6
Rule 7
Rule 8
Rule 9
Rule 10
Rule 11
Rule 12
Rule 13
Rule 14

Where:

Failure mode 1 graph : A and B

Failure mode 2 graph : C and D

Failure mode 3 graph : E and F

Failure mode 4 graph : G and H

Failure mode 5 graph : I and J

Failure mode 6 graph : K and L

Failure mode 7 graph : M and N

Failure mode 8 graph : O and P

Failure mode 9 graph : Q and R

Failure mode 10 graph : S and T

Failure mode 11 graph : U and V

Failure mode 12 graph : W and X

Failure mode 13 graph : Y and Z

Failure mode 14 graph : AA and AB

APPENDIX J

EQUIPMENT SPECIFICATIONS

1. Kobelco SK330

Specifications

Engine

Model	J08ETM-KSDL
Type	Direct injection, water-cooled, 4-cycle diesel engine with turbocharger, intercooler
No. of cylinders	6
Bore and stroke	112 mm x 130 mm
Displacement	7.684 L
Rated power output	197 kW/2,100 min^{-1} (ISO 9249)
	209 kW/2,100 min^{-1} (ISO 14396)
Max. torque	969 N·m/1,600 min^{-1} (ISO 9249)
	998 N·m/1,600 min^{-1} (ISO 14396)

Hydraulic System

Pump	
Type	Two variable displacement pumps + One gear pump
Max. discharge flow	2 x 294 L/min, 1 x 21 L/min
	Extra gear pump 1 x 43 L/min
Relief valve setting	
Boom, arm and bucket	34.3 MPa {350 kgf/cm²}
Power Boost	37.8 MPa {385 kgf/cm²}
Travel circuit	34.3 MPa {350 kgf/cm²}
Swing circuit	29.0 MPa {296 kgf/cm²}
Control circuit	5.0 MPa {50 kgf/cm²}
Pilot control pump	Gear type
Main control valve	8-spool
Oil cooler	Air cooled type

Swing System

Swing motor	Axial-piston motor
Brake	Hydraulic; locking automatically when the swing control lever is in neutral position
Parking brake	Oil disc brake, hydraulic operated automatically
Swing speed	10 min^{-1} {rpm}
Tail swing radius	3,600 mm
Min. front swing radius	4,310 mm

Travel System

Travel motors	2 x axial-piston, two-step motors
Travel brakes	Hydraulic brake per motor
Parking brakes	Oil disc brake per motor
Travel shoes	45 (48) each side
Travel speed	5.8/3.6 km/h
Drawbar pulling force	333 kN (ISO 7464)
Gradeability	70% {35°}

( ) show SK350LC

Cab & Control

Cab

All-weather, sound-suppressed steel cab mounted on the high suspension mounts filled with silicone oil and equipped with a heavy, insulated floor mat.

Control

Two hand levers and two foot pedals for travel

Two hand levers for excavating and swing

Electric rotary-type engine throttle

Boom, Arm & Bucket

Boom cylinders	140 mm x 1,550 mm
Arm cylinder	170 mm x 1,788 mm
Bucket cylinder	150 mm x 1,193 mm

Refilling Capacities & Lubrications

Fuel tank	503 L
Cooling system	35 L
Engine oil	28.5 L
Travel reduction gear	2 x 8.0 L
Swing reduction gear	7.4 L
Hydraulic oil tank	245 L tank oil level
	410 L hydraulic system

Attachments

Backhoe bucket and combination

Use			Backhoe bucket Normal digging		
Bucket capacity	Heaped (ISO7451)	m³	1.20	1.40	1.60
	Struck (ISO7451)	m³	0.84	1.00	1.20
Opening width	With side cutter	mm	1,240	1,420	1,570
	Without side cutter	mm	1,110	1,390	1,450
No. of teeth			4	5	5
Bucket weight		kg	930	1,080	1,140
Combination	2.60 m short arm		○	○	◎
	3.30 m standard arm		○	◎	△
	4.15 m long arm		○	△	×

◎ Standard ○ Recommend △ Loading only × Not recommended

15

Figure K.1. Kobelco SK330 specification A.

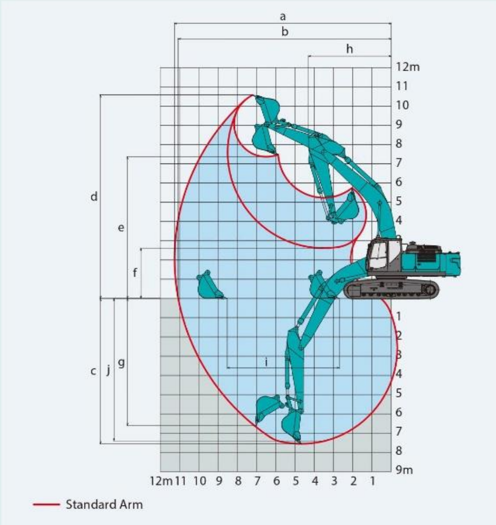
SK330 SK350LC

SK330-10 SK350LC-10

Working Ranges

Unit: m

Boom	6.50 m		
Arm / Range	Short 2.6 m	Standard 3.3 m	Long 4.15 m
a- Max. digging reach	10.61	11.26	11.97
b- Max. digging reach at ground level	10.4	11.06	11.79
c- Max. digging depth	6.86	7.56	8.41
d- Max. digging height	10.26	10.58	10.7
e- Max. dumping clearance	7.06	7.37	7.53
f- Min. dumping clearance	3.32	2.62	1.77
g- Max. vertical wall digging depth	5.84	6.61	7.15
h- Min. swing radius	4.45	4.31	4.43
i- Horizontal digging stroke at ground level	4.21	5.82	7.21
j- Digging depth for 2.4 m (8') flat bottom	6.67	7.4	8.27
Bucket capacity ISO heaped m³	1.6	1.4	1.2



Digging Force (ISO 6015)

Unit: kN (tf)

Arm length	Short 2.6 m	Standard 3.3 m	Long 4.15 m
Bucket digging force	221 244*	222 244*	221 243*
Arm crowding force	205 225*	163 180*	140 154*

*Power Boost engaged.

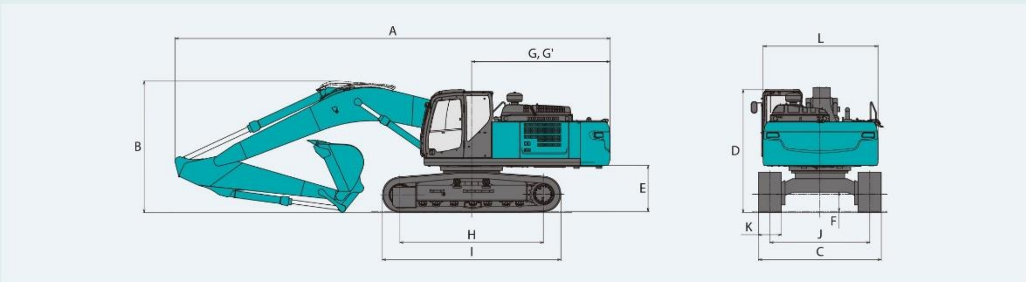
Dimensions

Unit: mm

	Arm length	Short 2.6 m	Standard 3.3 m	Long 4.15 m
A	Overall length	11,380	11,300	11,330
B	Overall height (to top of boom)	3,680	3,420	3,590
C	Overall width of crawler		3,190	
D	Overall height (to top of cab)		3,200	
E	Ground clearance of rear end*		1,190	
F	Ground clearance*		500	
G	Tail swing radius		3,600	

G'	Distance from center of swing to rear end		3,600
H	Tumbler distance	SK330	3,720
		SK350LC	4,050
I	Overall length of crawler	SK330	4,630
		SK350LC	4,960
J	Track gauge		2,590
K	Shoe width		600
L	Overall width of upperstructure		2,980

*Without including height of shoe



Operating Weight & Ground Pressure

In standard trim, with standard boom, 3.3 m arm, and 1.4 m³ ISO heaped bucket

Shaped			Triple grouser shoes (even height)		
Shoe width		mm	600	700	800
Overall width of crawler	SK330	mm	3,190	3,290	3,390
	SK350LC	mm	3,190	3,290	3,390
Ground pressure	SK330	kPa (kgf/cm²)	71	63	56
	SK350LC	kPa (kgf/cm²)	67	59	52
Operating weight	SK330	kg	35,200	36,300	36,700
	SK350LC	kg	35,900	36,800	37,200

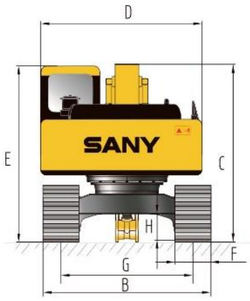
16

Figure K.2. Kobelco SK330 specification B

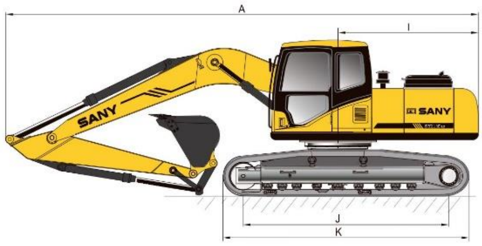
2. Sany SY365H

SY365H DIMENSIONS & SPECIFICATIONS

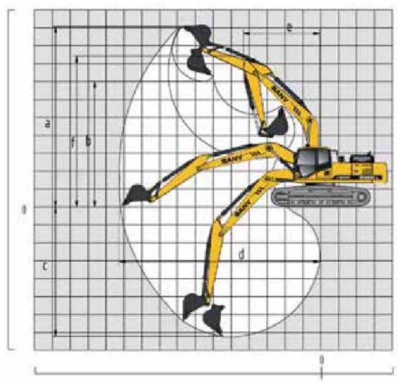
OVERALL DIMENSIONS		
A	Transport Length	9728 mm
B	Transport Width	3080 mm
C	Transport Height	3675 mm
D	Upper Width	3145 mm
E	Tail Swing Radius	3330 mm
F	Min. Ground Clearance	550 mm



WORKING RANGE		
a	Maximum Digging Height	10135 mm
b	Maximum Dumping Height	7180 mm
c	Maximum Digging Depth	7330 mm
d	Maximum Vertical Digging Depth	5850 mm
e	Maximum Digging Reach	11070 mm
f	Minimum Swing Radius	3800 mm
g	Height at min.swing radius	7940 mm



MACHINE PARAMETERS	
Operating Weight	36200 kg
Engine Type	Cummins QSL9
Engine Max Power (Gross)	205/2200 kW/rpm
Engine Max Torque	1213/1500 N·m/rpm
Engine Displacement	9 L
Emission Standard	Tier 4 Final
Swing Speed	9.5 rpm
Travel Speed	3.2/5.4 km/h
Fuel Tank Capacity	540 L
Hydraulic Tank Capacity	340 L
Engine Oil Capacity	21.5 L
Gradeability	35°
Bucket Digging Force	200 kN
Arm Digging Force	169 kN
Bucket Capacity	1.5 m³
Boom Length	6470 mm
Arm Length	3200 mm
Track Gauge	2590 mm
Track Length	5065 mm

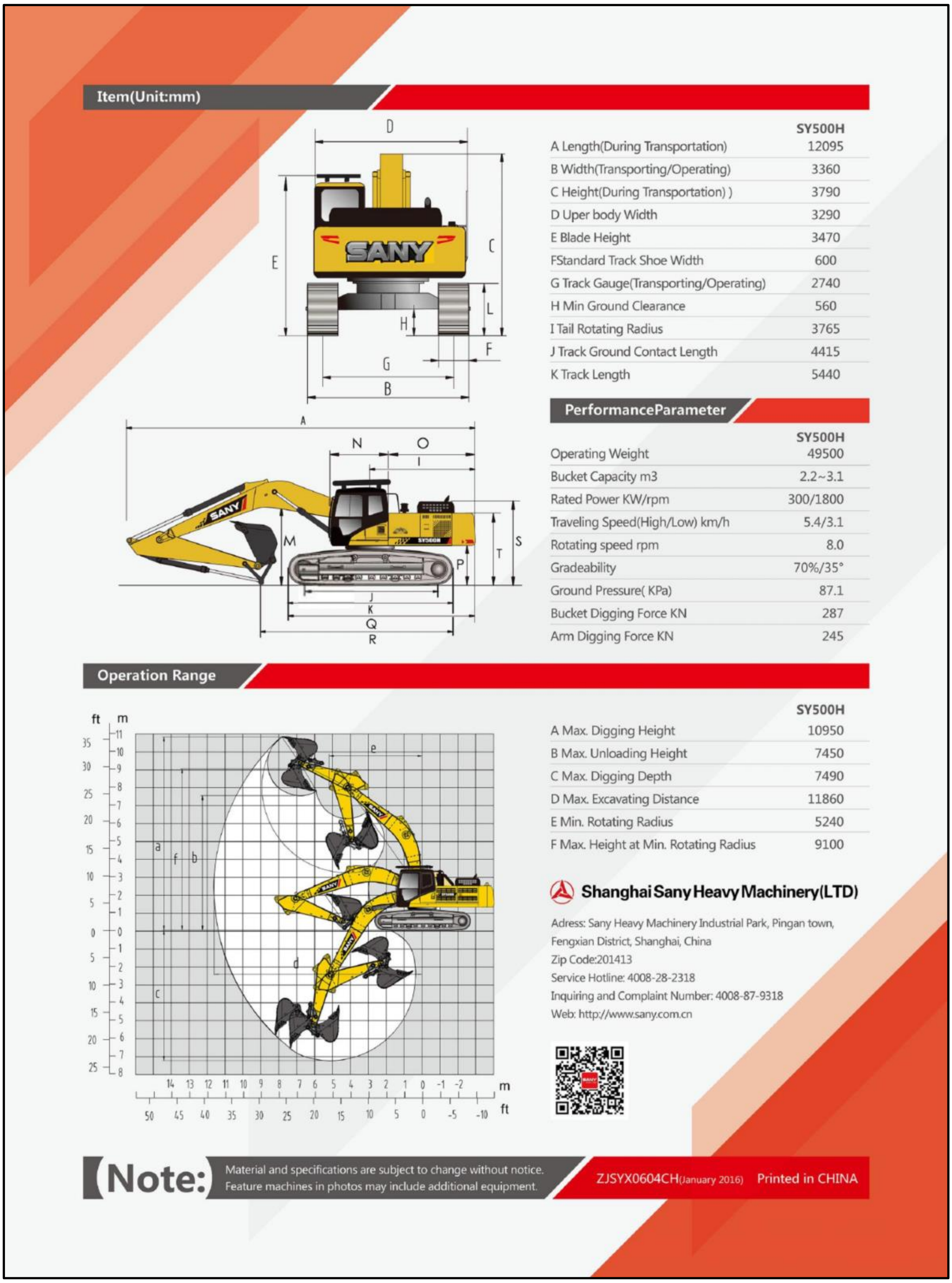


Not all products are available in all markets. Under our policy of continuous improvement, Sany reserve the right to change specifications and design without prior notice. The illustrations do not necessarily show the standard version of the machine.

SANY HEAVY MACHINERY (AUSTRALIA)
21 EFFICIENT DRIVE, TRUGANINA VIC 3029
PHONE 0400 724 483 WWW.SANYAUSTRALIA.COM.AU

Figure K.3. Sany SY365H specification

3. Sany SY500H



Item(Unit:mm)

	SY500H
A Length(During Transportation)	12095
B Width(Transporting/Operating)	3360
C Height(During Transportation))	3790
D Uper body Width	3290
E Blade Height	3470
FStandard Track Shoe Width	600
G Track Gauge(Transporting/Operating)	2740
H Min Ground Clearance	560
I Tail Rotating Radius	3765
J Track Ground Contact Length	4415
K Track Length	5440

PerformanceParameter

	SY500H
Operating Weight	49500
Bucket Capacity m3	2.2~3.1
Rated Power KW/rpm	300/1800
Traveling Speed(High/Low) km/h	5.4/3.1
Rotating speed rpm	8.0
Gradeability	70%/35°
Ground Pressure(KPa)	87.1
Bucket Digging Force KN	287
Arm Digging Force KN	245

Operation Range

	SY500H
A Max. Digging Height	10950
B Max. Unloading Height	7450
C Max. Digging Depth	7490
D Max. Excavating Distance	11860
E Min. Rotating Radius	5240
F Max. Height at Min. Rotating Radius	9100

Shanghai Sany Heavy Machinery(LTD)

Adress: Sany Heavy Machinery Industrial Park, Pingan town, Fengxian District, Shanghai, China
Zip Code:201413
Service Hotline: 4008-28-2318
Inquiring and Complaint Number: 4008-87-9318
Web: http://www.sany.com.cn

Note: Material and specifications are subject to change without notice. Feature machines in photos may include additional equipment.

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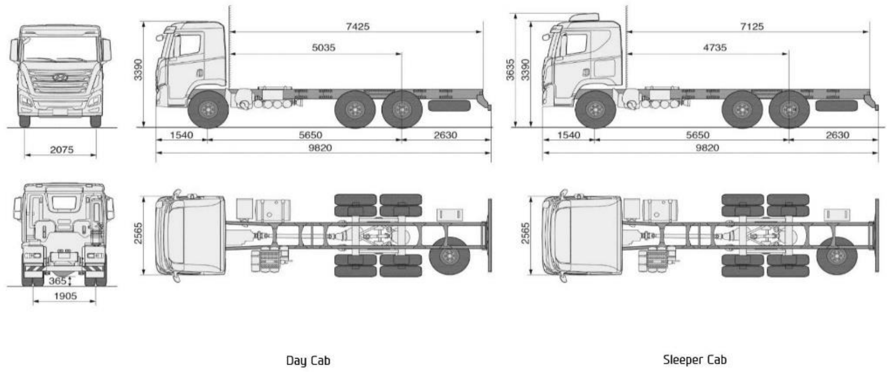
Figure K.4. Sany SY500H specification

4. Hyundai Xcient 400

400 Dump Long **Wheelbase**

HYUNDAI XCINT



Model		Q340.400 / H380.400 / H420.400 / P410.400					
Vehicle Type		Dump					
Cab Type		Day / Sleeper					
Wheel Base		Long					
Drive System		LHD / RHD, 6 x 4					
Application Engines		D6AC	D6HB3H	D6HA3H	D6HA42	D6CA41	D6CB41
Dimensions (mm)							
Wheel Base		5,650 (4,300 + 1,350)					
Overall	Length	9,820					
	Width	2,565					
	Height	3,390					
Wheel Tread	Front	2,075					
	Rear	1,905					
Overhang	Front	1,540					
	Rear (Frame)	2,390					
C.A (Cab to rear Axle)		5,035 / 4,735					
C.E (Cab to End of frame)		7,425 / 7,125					
Min. Ground Clearance		365					
Min. Turning Radius	m	8.9					
Weight (kg)							
Chassis Cab Weight		9,145/9,215		9,245 / 9,315		9,395 / 9,465	
(Day / Sleeper)	Front	4,500/4,560		4,600 / 4,660		4,755 / 4,815	
	Rear	4,645/4,655		4,645 / 4,655		4,640 / 4,650	
** Max Gross Vehicle Weight		40,000					
	Front	8,000					
	Rear	32,000					

** Max. GVW includes the front & rear axle loads based on the tubless radial tires permissible load.

Hyundai Commercial Vehicle SPECIFICATIONS_ 15

Figure K.5. Hyundai Xcient 400 specification A

HYUNDAI XCIENT_310/400 Dump

Chassis Specifications

Engine

Model		D6AC	D6HB38	D6HB3H	D6HA38	D6HA3H	D6HA40A	D6HA42	D6CA41	D6CB41
Type		Turbo Charger Intercooler 4 stroke-cycle, water-cooled, direct-injection diesel engine								
Number of Cylinder		6 in-line								
Piston Displacement (cc)		11,149	9,960						12,920	12,344
Bore x Stmke (mm)		130 x 140	122 x 142						133 x 155	130 x 155
Compression Ratio		16.5 : 1	17 : 1							
Max. Power** (ps/rpm)	EuroI	340/2,200								
	EuroII	-	-	-	-	-	-	-	410/1,900	-
	Euro III	-	380/2,000	380/2,000	-	-	-	-	-	410/1,900
	Euro IV	-	-	-	380/2,000	380/2,000	-	-	-	-
	Euro V	-	-	-	-	-	400/1,800	420/1,800	-	-
Max. Torque ** (kg.m/rpm)	EuroI	140/1,400								
	EuroII	-	-	-	-	-	-	-	188/1,500	-
	Euro III	-	160/1,200	173/1,200	-	-	-	-	-	188/1,200
	Euro IV	-	-	-	160/1,200	173/1,200	-	-	-	-
	Euro V	-	-	-	-	-	178/1,100	200/1,100	-	-
Cooling System	General	Pressure type with thermostat, Forced circulation by centrifugal water pump								
	Radiator	Corrugated fin type with pressure cap and condenser tank								
Electrical System	Battery	12V x 2, 150 AH at 20 Hr rates								
	Alternator	24V-60A	24V-70A						24V-90A	
	Starter	24V- 5.5kW	24V-6.0kW							
Fuel System	Injection pump	In-line type	EUI system							
	Governor	All Speed type	Electronic Control							
	Fuel filter	Spin-on type								
Oil System	Lubrication	Forced lubrication by gear pump								
	Oil filter	Full flow and bypass type with paper element								
	Oil cooler	Water cooled, plate fin type								
	Oil grade	API service classification CF-4 or above								
Valve System		Single Overhead Valve, Two valves per cylinder								

** Max. Power and Torque of engine may vary according to each country.

Clutch

Model	.310 / .400
Type	Hydraulic control with Air pressure assistance, Coil spring, Single dry plate, Pre-Damper
Facing Material	Non-Asbestos
Facing Size (mm) : Outside dia x Inside dia	ø430 x ø242

Figure K.6. Hyundai Xcient 400 specification B

HYUNDAI XCIENT_310/400 Dump

Transmission

Model		.310 / .400								
Application Engines		D6AC	D6HB38	D6HB3H	D6HA38	D6HA3H	D6HA40A	D6HA42	D6CA41	D6CB41
	M12S6	•								
T/M Application	H160S6		•		•					
• : STD	H160S 2X5	o	o		o					
o : OPT	ZF16S1830			•		•			•	•
	ZF16S2330							•		
	FSO10309						•			

Model		M12S6 / H160S6	H160S 2x5	ZF16S1830	ZF16S2330	FSO10309
Type		6 forward and 1 reverse speed	10 forward and 2 reverse speed	16 forward and 2 reverse speed		9 forward and 1 reverse speed
Gear Ratio	1st (High / Low)	7.213	9.153 / 7.145	13.80 / 11.54	16.41 / 13.80	10.58 / 7.38
	2nd (High / Low)	4.178	4,783 / 3,733	9.49 / 7.93	11.28 / 9.49	5.22 / 3.71
	3rd (High / Low)	2.587	2,765 / 2,158	6.53 / 5.46	7.76 / 6.53	2.73 / 1.99
	4th (High / Low)	1.621	1,666 / 1,301	4.57 / 3.82	5.43 / 4.57	1.41 / 1.00
	5th (High / Low)	1.000	1,000 / 0.780	3.02 / 2.53	3.59 / 3.02	0.74
	6th (High / Low)	0.702	-	2.08 / 1.74	2.47 / 2.08	-
	7th (High / Low)	-	-	1.43 / 1.20	1.70 / 1.43	-
	8th (High / Low)	-	-	1.00 / 0.84	1.19 / 1.00	-
	Reverse	7.081	8,105 / 6,327	12.92 / 10.80	15.36 / 12.92	10.59
Gear Oil		API service classification GL-4 or SAE service classification 80W (90 ; Tropical zones only)				
T.G.S. (Transmission Gear Shift)		Floor shift, Mechanical remote control				

Rear Axle

Axle Model		D12HT	THR20ST
Type		Full floating type	
Capacity	Kg	13,000 x 2	16,000 x 2
Final Reduction	Type	Single Reduction, Hypoid gear	Hub Reduction, Hypoid gear
Gear	G/Ratio	4.875 / 5.571 / 6.166	6.676

Front Axle

Type		Reverse Elliot type " I " beam
Capacity		8,000

Tire & Wheel

Type		Single Front, Dual Rear	
Tire	Front / Rear	12R22.5-16PR	12.00R24-18PR
Wheel	Front/ Rear	22.5 x 8.25	24 x 8.5v

Steering

Type		2-Spoke, Ball-nut type, Tilt & Telescopic steering column
Tilting Angle		9 °
Turning Angle	Inner	Front 1st axle 44 ° / Front 2nd axle 29 °
	Outer	Front 1st axle 34 ° / Front 2nd axle 24 °

Hyundai Commercial Vehicle SPEGFICATIONS_ 17

Figure K.7. Hyundai Xcient 400 specification C

HYUNDAI XCIENT_310/400 Dump

Service Brake			
Model		.310	.400
Actuation		Full Air, Dual circuit fixed S cam with spring loaded chambers	
Size (mm)	Front	Drum dia. x Lining width x Lining thickness : ø410 x 156 x 19	
	Rear	Drum dia. x Lining width x Lining thickness : ø410 x 220 x 19	
Total lining area		9,633㎠	
Parking Brake			
Actuation		Spring loaded type chamber on the front wheel and the 1st/2nd rear wheel	
Size (mm)		ø410 x 220 x 19	
Total lining area		9,633㎠	
Exhaust Brake			
Type		Air operated, butterfly valve type	
Suspension			
Type	Front / Rear	Semi-elliptic, laminated leaf springs with shackle link(Multi leaf spring) or Parabolic Spring (without D6AC)	Semi-elliptic, laminated leaf springs with shackle link (Multi leaf spring)
Shock absorber		Hydraulic double acting telescopic type on the front axle	
Exhaust system			
General		Conventional type muffler	
Tail pipe		Droptail type, blowing to chassis rearward	
Fuel tank			
Capacity		400 liter	
Material		Steel	
Frame			
Type		"H" type frame with channel sectional side rail & cross members, side rail is reinforced with outer stiffeners	
Main side rail (mm)		Depth x Flange x Thickness : 300 x 90 x 8 t	
Dump Body			
General		Steel Structure	
Dump Volume		15.67m³ (Length x Width x Height : 5,220 x 2,300 x 1306)	
Dumping Mechanism		Telescopic	
Dumping Angle		53.5 °	

18 _Hyundai Commercial Vehicle SPECIFICATIONS

Figure K.8. Hyundai Xcient 400 specification D

5. Hino FM 260 JD

Sekilas	Mekanikal	Dimensi
Sekilas Gambar	Performa	Tangki Solar
	Kecepatan Maksimum : 87	Kapasitas : 200
Tipe Karoseri	Daya Tanjak (tan Ø) : 52	Dimensi (mm)
Ambulans	Model Mesin	Jarak Sumbu Roda : 4030 + 1350
Arm Roll	Model : J08E-UF	Cabin to End : 3875
Taxi	Tipe : Mesin Diesel 4 Langkah Segaris; Direct Injection; Turbo Charger Intercooler	Total Panjang : 8645
Mobil Boks/Bak	Tenaga Maksimum (PS/rpm) : 260 / 2500	Total Lebar : 2495
Truk Logging	Torsi Maksimum (Kgm/rpm) : 76 / 1500	Total Tinggi : 2780
Truk Sampah	Jumlah Silinder : 6	Lebar Jejak Depan : 2050
Mesin Derek	Diameter x Langkah Piston (mm) : 112 x 130	Lebar Jejak Belakang : 1875
Dump	Isi Silinder (cc) : 7684	Julur Depan : 1280
Los Bak	Kopling	Julur Belakang : 1985
Tangki High Blow	Tipe : Pelat Kering Tunggal dengan Coil Spring	Berat Chassis (kg)
Tangki	Diameter Cakram : 380	Depan : 3160
Molen	Transmisi	Belakang : 3940
Bak Terbuka	Tipe : M009DD	Berat Kosong : 7100
Boks Berpendingin	Perbandingan Gigi :	GVWR / GCWR : 26000
Sky Lift	C : 14.056	
Angkut Kendaraan	ke-1 : 9.647	
Mobil Penarik	ke-2 : 6.993	
Mobil Derek	ke-3 : 5.021	
Bus		

Figure K.9. Hino FM 260 JD A

Fire Fighting	ke-4 : 3.636
	ke-5 : 2.653
	ke-6 : 1.923
	ke-7 : 1.380
	ke-8 : 1.000
	Mundur 13.636
	Kemudi
	Tipe : Integral Power Steering
	Minimal Radius Putar : 8.5
	Sumbu
	Belakang : Full Floating Tipe Hypoid Gear
	Depan : Reverse Elliot, I-Section Beam
	Perbandingan Gigi Akhir : 6.428
	Sistem Penggerak : -
	Roda & Ban
	Ukuran Rim : 20X7.50V-165
	Ukuran Ban : 11.00-20-16PR
	Jumlah Ban : 10 + 1(Cadangan)
	Suspensi
	Depan & Belakang : Rigid Axle dengan Pegas Daun Semi Elliptic,Tipe Trunnion Suspensi, Rigid Axle dengan Pegas Daun Semi Elliptic
	Sistim Listrik Accu
	Accu : 12V-65AH×2

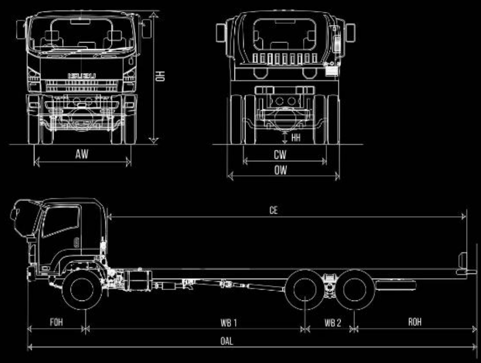
Figure K.10. Hino FM 260 JD B

6. Isuzu Giga FV234

SPECIFICATION

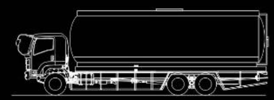
			FVZ 34 N HP 6.1 (N)	FVZ 34 U HP (N)	FVZ 34 L HP MX (N)
DIMENSION					
Over all Length (OAL)		mm	8.650	11.945	7.560
Over all Width (OW)		mm	2.485	2.485	2.485
Over all Height (OH)		mm	2.975	2.975	2.965
Wheel Base (WB1+WB2)		mm	4.115+1.370	5.825+1.370	3.565+1.370
Front Over Hang (FOH)		mm	1.250	1.250	1.250
Rear Over Hang (ROH)		mm	1.915	3.500	1.375
Cabin to end (CE)		mm	6.545	9.840	5.460
Min. Clearence (HH)		mm	285	285	275
Chassis width		mm	870x305x7.8	870x305x7.8	870x305x7.8
Tread	Front (AW)	mm	2.060	2.060	2.060
	Rear (CW)	mm	1.850	1.850	1.850
WEIGHT					
Vehicle Mass	Total	Kg	7.430	8.070	7.270
Gross Vehicle Mass (GVW)		Kg	26.000	26.000	26.000
ENGINE					
Engine Model			6HK1 TCS	6HK1-TCS	6HK1 TCS
Type			6Cyl, OHC, Dir In	6Cyl, OHC, Dir Inj	6Cyl, OHC, Dir In
Bore and Stroke		mm	115x125	115x125	115x125
Piston Displacement		cc	7.790	7.790	7.790
Max. Output		PS/rpm	285/2400	285/2400	285/2400
Max. Torque		Kgm/rpm	90/1450-2400	90/1450-2400	90/1450-2400
CLUTCH DIAMETER		mm	380	380	380
TRANSMISSION					
Transmission Model/ Brand			ES11109DD	ES11109DD	ES11109DD
Transmission Operational Type			Double H	Double H	Double H
		Low	12.638	12.638	12.638
		1st	8.807	8.807	8.807
		2nd	6.550	6.550	6.550
Gear Ratio		3rd	4.768	4.768	4.768
		4th	3.548	3.548	3.548
		5th	2.482	2.482	2.482
		6th	1.846	1.846	1.846
		7th	1.344	1.344	1.344
		8th	1.000	1.000	1.000
		9th			
		Rev.	13.210	13.210	13.210
Final Gear Ratio		to 1	6.143 / 6.428 (opt.)	6.143	6.143
AXLE					
Capacity Rear Axle		Kg	20,000	20,000	20,000
Capacity Front Axle		Kg	6,000	6,000	6,000
BRAKE					
Type			Full Air	Full Air	Full Air
TYRE					
Front			Single 11.00-20-16PR	Single 11.00-20-16PR	Single 11.00-20-16PR
Rear			Double 11.00-20-16PR	Double 11.00-20-16PR	Double 11.00-20-16PR
Type			Rib Lug	Rib Lug	Rib Lug
Disk Wheel Size			10STUD 20X7.50T	10STUD 20X7.50T	10STUD 20X7.50T
OTHERS					
Fuel Tank Capacity		Liter	200	200	200
Min. Turning Radius		m	8.4	10.8	7.605
Max. Gradeability		%	45	45	45
Max. Speed		Km/h	83	83	83
Emission			Euro 2	Euro 2	Euro 2
Body Color			White	White	White
Cabin Suspension Type			Solid Rubber	Solid Rubber	Solid Rubber
Underguard & Seeat Suspension			Yes	Yes	Yes
Warranty			1 Year/ 100.000 Km	1 Year/ 100.000 Km	1 Year/ 100.000 Km
Alternator		V-A	24-60	24-60	24-60

DIMENSI

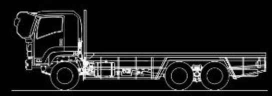


CONTOH APLIKASI

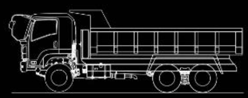
- TANK



- FLAT BED



- DUMP TRUCK



- MIXER

* Untuk meingkatkan mutu dan penyesuaian dengan perkembangan teknologi, spesifikasi dapat berubah sewaktu waktu tanpa pemberitahuan
** Illustrasi merupakan contoh sebagian aplikasi di lapangan

07.2019

APPENDIX K

ROAD GRADE AND MACHINE FORMULA

Premise I: Hill geometry affects hauler ability to climb a hill

Premise II: Hauler ability to climb a hill is affected by engine power and torque which has a maximum value. Hauler also needs energy at bottom until it reaches its maximum range.

With assumption that hauler work in a close system (the effect of aerodynamic is ignored), the law of conservation of mechanical energy shows that:

$$ME_1 = ME_2 \quad \text{(L.1)}$$

Which are:

$$ME = KE + PE \quad \text{(L.2)}$$

$$KE = \frac{1}{2}mv^2 \quad \text{(L.3)}$$

$$PE = mgh \quad \text{(L.4)}$$

Then:

$$\frac{1}{2}m{v^2}_1 + mgh_1 = \frac{1}{2}m{v^2}_2 + mgh_2 \quad \text{(L.5)}$$

Mass of hauler is constant, then the formula become:

$$\frac{1}{2}{v^2}_1 + gh_1 = \frac{1}{2}{v^2}_2 + gh_2 \quad \text{(L.6)}$$

$$\frac{1}{2}({v^2}_1 - {v^2}_2) = g(h_2 - h_1) \quad \text{(L.7)}$$

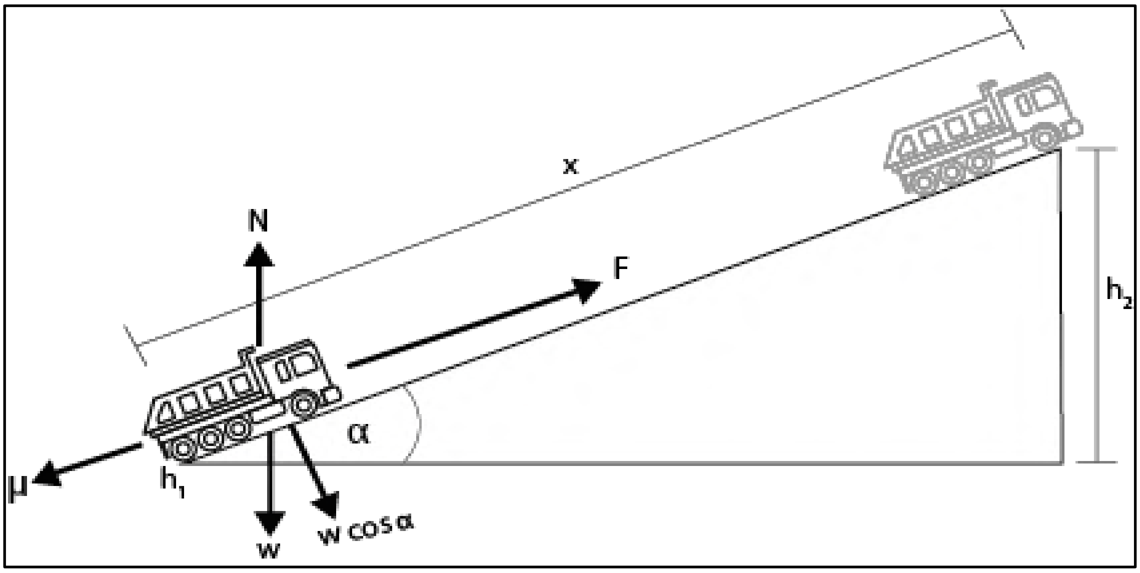


Figure L.1 Force in inclined plane

Based on Figure L1 h_1 is 0 and h_2 equal to $x\ sin\alpha$, then:

$$\frac{1}{2}({v^2}_1 - {v^2}_2) = g(x\ sin\alpha) \qquad \text{(L.8)}$$

$$\frac{(v_1+v_2)(v_1-v_2)}{2} = g(x\ sin\alpha) \qquad \text{(L.9)}$$

Premise II says that engine power is affecting the hauler ability, then power formula has to be inputed:

$$P = F\bar{v} \qquad \text{(L.10)}$$

$$P = F\frac{(v_1+v_2)}{2} \qquad \text{(L.11)}$$

Based on Figure L1 F is affected by resitance (μ) as reducing factor, then Equation L11 become:

$$P = (F-\mu)\left(\frac{(v_1+v_2)}{2}\right) \qquad \text{(L.12)}$$

$$\frac{(v_1+v_2)}{2} = \frac{P}{(F-\mu)} \qquad \text{(L.13)}$$

Force can be related to torque with equation:

$$F = \frac{T}{r_1} \qquad \text{(L.14)}$$

Subtitude Equation L.14 to L.13, become:

$$\frac{(v_1+v_2)}{2} = \frac{P}{(\frac{T}{r_1}-\mu)} \qquad \text{(L.15)}$$

Equation L.15 is substituted into Equation L.9 become:

$$\frac{P}{(\frac{T}{r_1}-\mu)}(v_1 - v) = g(x\ sin\alpha) \qquad \text{(L.16)}$$

$$\frac{P}{\left(\frac{T-\mu r_1}{r_1}\right)}(v_1 - v_2) = g(x\ sin\alpha) \qquad \text{(L.17)}$$

Linear motion in hauler have to related to angular motion in engine, then:

$$v = r\omega \qquad \text{(L.18)}$$

$$\omega = \frac{2\pi}{60}N \qquad \text{(L.19)}$$

$$v = r\frac{2\pi}{60}N \qquad \text{(L.20)}$$

Equation L.20 is substituted into Equation L.17 become:

$$\frac{P}{\left(\frac{T-\mu r_1}{r_1}\right)}(r_2\frac{2\pi}{60}(N_1 - N_2) \ = g(x\ sin\alpha) \quad \text{(L.21)}$$

Torque in hauler has to be related to torque in engine with:

$$T = \eta\, T_{eng} \quad \text{(L.22)}$$

$$T_{eng} = \frac{P}{\pi\Delta N}30 \quad \text{(L.23)}$$

$$T = \eta\ \frac{P}{\pi\Delta N}30 \quad \text{(L.24)}$$

Then the formula become:

$$\frac{P}{\left(\frac{\left(\eta\,\frac{P}{\pi\Delta N}30\right)-(\mu r_1)}{r_1}\right)}(r_2\frac{2\pi}{60}(N_1 - N_2)) \ = g(x\sin\alpha) \quad \text{(L.25)}$$

$$P(r_2 r_1 2\pi(N_1 - N_2)) \ = g(x\ sin\ \alpha)\left(\left(\eta\ \frac{P}{\pi\Delta N}30\right) - (\mu r_1)\right)(60) \quad \text{(L.26)}$$

Because α is relatively small then $\sin\alpha = \alpha_{\%}$ and $\mu = w(r + \alpha_{\%})$, the formula become:

$$P(r_2 r_1 2\pi(N_1 - N_2)) \ = g(x\ \alpha_{\%})\left(\left(\eta\ \frac{P}{\pi\Delta N}30\right) - ((w(r + \alpha_{\%}))r_1)\right)(60) \quad \text{(L.27)}$$

Thus, the maximum displacement of hauler can be calculated with:

$$x \ = \frac{P(r_2 r_1 2\pi(N_1 - N_2))}{(g\ \alpha_{\%})\left(\left(\eta\,\frac{P}{\pi\Delta N}30\right)-((w(r+\alpha_{\%}))r_1)\right)(60)} \quad \text{(L.28)}$$

Informations:

x : displacement (m)

P : power (watt)

r_1 : wheel radius (m)

r_2 : engine radius (m)

N_1 : engine angular velocity start (rpm)

N_2 : engine angular velocity end (rpm)

g : gravitational acceleration ($^m/_{s^2}$)

η : gear ratio

ΔN: engine angular velocity interval (rpm)

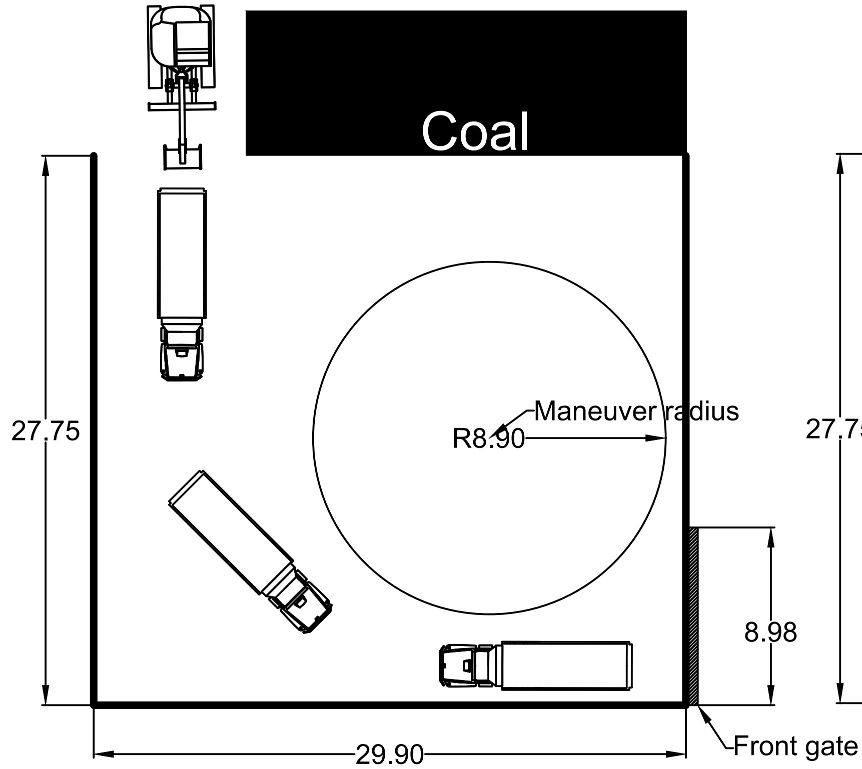
w : hauler weight (N)

r : rolling resistance coefficient

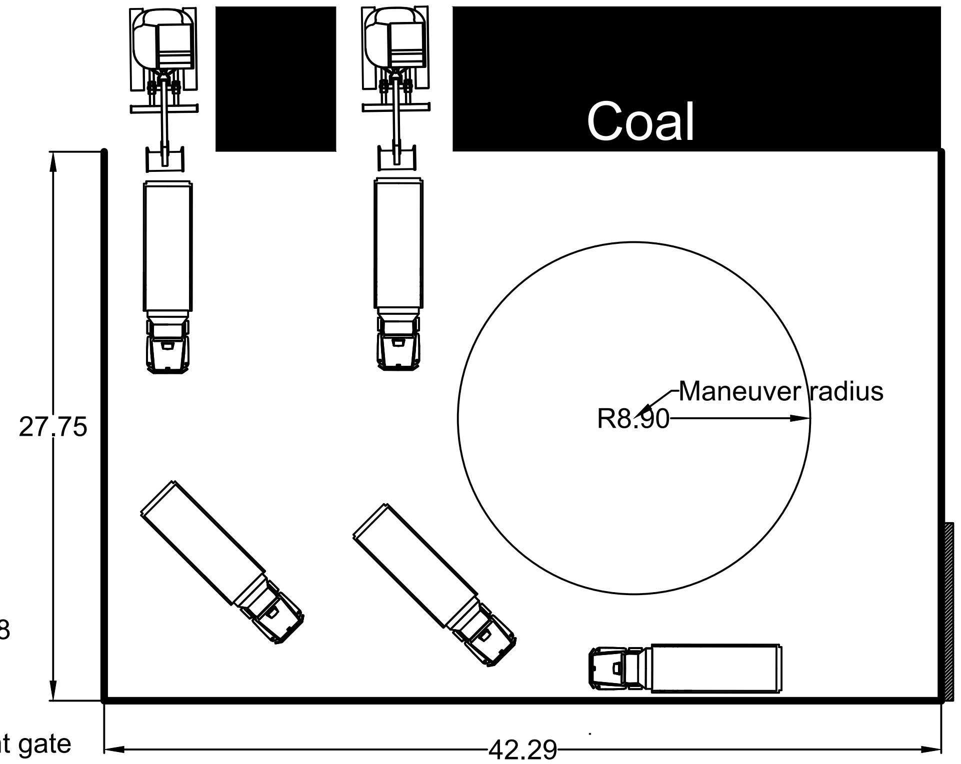
$\alpha_{\%}$: road grade (%)

APPENDIX L

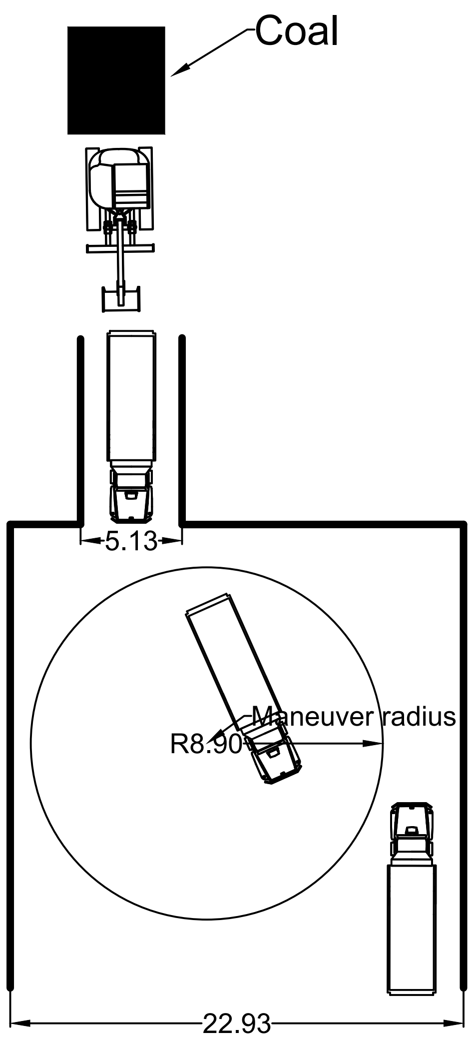
FRONT GEOMETRY RECOMMENDATION



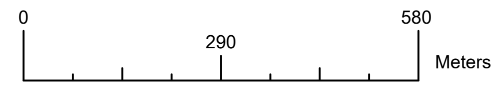
Single fleet



Double fleet



Particular condition



Hauler width = 2.57 m
Hauler length = 9.82 m
Turn radius = 8.90 m
Turn angle = 44° (outer)
34° (inner)

Unit : Meter
Sheet size: A3

MINING ENGINEERING DEPARTMENT
FACULTY OF ENGINEERING
HASANUDDIN UNIVERSITY
2022

THESIS

COAL PRODUCTION FAILURE RISK IDENTIFICATION USING FUZZY FMEA (FAILURE MODE EFFECT ANALYSIS) AT PT SEBUKU TANJUNG COAL SOUTH KALIMANTAN

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FRONT GEOMETRY RECOMMENDATION

APPENDIX	PAGE
L	161