Constructing a Bridge
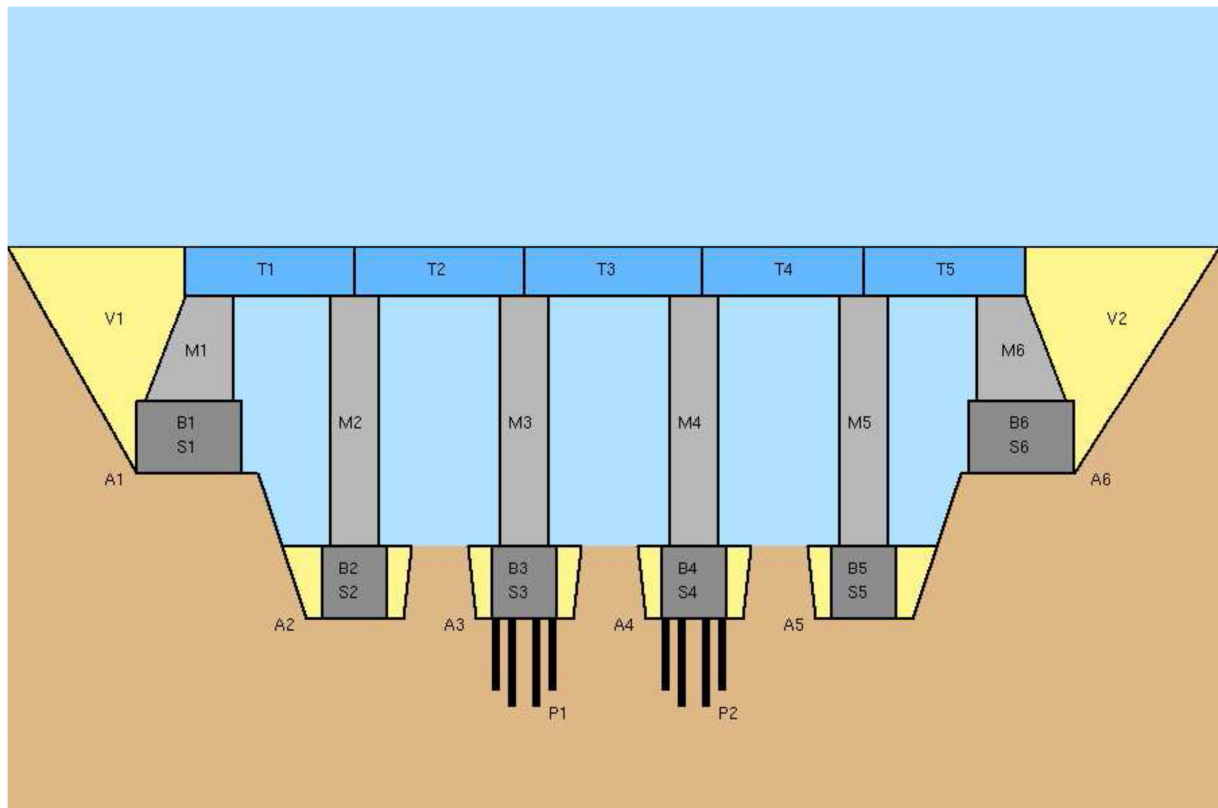
The following problem is taken from: Martin Bartusch. *Optimierung von Netzplänen mit Anordnungsbeziehungen beiknappen Betriebsmitteln*. PhD thesis, Universität Passau, Fakultät für Mathematikund Informatik, 1983.

The problem is to schedule the construction of the bridge shown in the following figure.

Problem Specification

The problem is specified as shown in in the following table. From this table we derive precedence and capacity constraints as in the sections before. We also assume that a resource cannot handle more than one activity at a time. Such a kind of resource is also known as a *unary resource*.

Unary resources

Due to some peculiarities of the problem, we have the following additional constraints:

1. The time between the completion of the formwork and the completion of the corresponding concrete foundation is at most 4 days.
2. Between the end of a particular foundation and the beginning of the corresponding formwork can at most 3 days elapse.
3. The erection of the temporary housing must begin at least six days before each formwork.
4. The removal of the temporary housing can start at most two days before the end of the last masonry.
5. The delivery of the preformed bearers occurs exactly 30 days after the beginning of the project.

N°	Name	Description	Duration	Precedence	Resource
1	pa	beginning of project	0	-	no resource
2	a1	excavation (abutment 1)	4	pa	excavator
3	a2	excavation (pillar 1)	2	pa	excavator
4	a3	excavation (pillar 2)	2	pa	excavator
5	a4	excavation (pillar 3)	2	pa	excavator
6	a5	excavation (pillar 4)	2	pa	excavator
7	a6	excavation (abutment 2)	5	pa	excavator
8	p1	foundation piles 2	20	a3	pile driver
9	p2	foundation piles 3	13	a4	pile driver
10	ue	erection of temporary housing	10	pa	no resource
11	s1	formwork (abutment 1)	8	a1	carpentry
12	s2	formwork (pillar 1)	4	a2	carpentry
13	s3	formwork (pillar 2)	4	p1	carpentry
14	s4	formwork (pillar 3)	4	p2	carpentry
15	s5	formwork (pillar 4)	4	a5	carpentry
16	s6	formwork (abutment 2)	10	a6	carpentry
17	b1	concrete foundation (abutment 1)	1	s1	concrete mixer
18	b2	concrete foundation (pillar 1)	1	s2	concrete mixer
19	b3	concrete foundation (pillar 2)	1	s3	concrete mixer
20	b4	concrete foundation (pillar 3)	1	s4	concrete mixer
21	b5	concrete foundation (pillar 4)	1	s5	concrete mixer
22	b6	concrete foundation (abutment 2)	1	s6	concrete mixer
23	ab1	concrete setting time (abutment 1)	1	b1	no resource
24	ab2	concrete setting time (pillar 1)	1	b2	no resource
25	ab3	concrete setting time (pillar 2)	1	b3	no resource
26	ab4	concrete setting time (pillar 3)	1	b4	no resource
27	ab5	concrete setting time (pillar 4)	1	b5	no resource
28	ab6	concrete setting time (abutment 2)	1	b6	no resource
29	m1	masonry work (abutment 1)	16	ab1	bricklaying
30	m2	masonry work (pillar 1)	8	ab2	bricklaying
31	m3	masonry work (pillar 2)	8	ab3	bricklaying
32	m4	masonry work (pillar 3)	8	ab4	bricklaying
33	m5	masonry work (pillar 4)	8	ab5	bricklaying
34	m6	masonry work (abutment 2)	20	ab6	bricklaying
35	l	delivery of the preformed bearers	2	-	crane
36	t1	positioning (preformed bearer 1)	12	m1, m2, l	crane
37	t2	positioning (preformed bearer 2)	12	m2, m3, l	crane
38	t3	positioning (preformed bearer 3)	12	m3, m4, l	crane
39	t4	positioning (preformed bearer 4)	12	m4, m5, l	crane
40	t5	positioning (preformed bearer 5)	12	m5, m6, l	crane
41	ua	removal of the temporary housing	10	-	no resource
42	v1	filling 1	15	t1	caterpillar
43	v2	filling 2	10	t5	caterpillar
44	pe	end of project	0	t2, t3, t4, v1, v2, ua	no resource