UNIVERSITI MALAYSIA PERLIS

PEMBANGUNAN LUKISAN SIAP BINA (AS BUILT DRAWINGS) MENGGUNAKAN PERISIAN BIM (AUTODESK REVIT)

Zul-Atfi Ismail

Technical Report

TECHNICAL REPORT

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Penerbit Universiti Malaysia Perlis
Kangar • 2020

e-ISBN 978-967-2829-07-2

Published by:

Penerbit UniMAP, Universiti Malaysia Perlis
Tingkat 10, Bangunan KWSP
Jalan Bukit Lagi,
01000 Kangar, Perlis. MALAYSIA.

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KANDUNGAN

PENGHARGAAN

Terlebih dahulu saya ingin mengucapkan syukur ke hadrat Ilahi kerana dengan limpah dan kurniaNya maka saya dapat menyiapkan laporan teknikal ini dengan jayanya dalam masa yang diperuntukkan.

Dikesempatan ini juga ingin saya mengucapkan terima kasih yang tidak terhingga kepada Prof Madya Dr. Azrul A. Mutalib dan Dr. Noraini Hamzah untuk kajian saya di atas. Segala yang dihasilkan daripada kerjasama beliau amat berguna dalam menjayakan projek perundingan ini.

Turut tidak saya lupakan sahabat-sahabat seperjuangan yang telah memberi sokongan dan pendapat. Akhir kata, terima kasih yang tidak terhingga sekali lagi kepada semua yang terlibat dalam menjayakan laporan teknikal ini.

PRAKATA

Terima kasih Tuhan, iaitu Allah SWT, yang memberi penulis inspirasi dan kekuatan untuk menyiapkan penulisan buku ini.

Laporan ini ditulis dengan harapan agar pelajar dan orang awam terus mempelajari dan mengadaptasi pengetahuan Pemodelan Maklumat Bangunan (BIM) sebagai ilmu tambahan mereka dan kerjaya mereka di masa hadapan. Sepanjang bekerja sebagai pensyarah di UniMAP, penulis sering bertemu dengan pelajar yang kurang yakin dengan amalan aplikasi perisian mereka dan tidak menyedari peluang dan kelebihan penggunaan Teknologi Maklumat (IT) dalam pembinaan kerana kurangnya minat untuk belajar dan banyak faktor kelemahan lain.

Penulis berminat untuk menulis topik ini berdasarkan pengalaman menjalankan konsultansi dalam bidang BIM. Beliau juga mempunyai pengalaman menggunakan perisian BIM semasa bekerja di syarikat pembinaan. Penulis percaya bahawa pengetahuan dan pengalaman mungkin tidak begitu berharga selagi penulis tidak dapat menyusun semula dalam bentuk buku dengan menggunakan bahasa yang mudah, ringkas dan menarik.

Dalam usaha menyiapkan buku ini dan melalui masa-masa sukar dari semasa ke semasa, penulis berasa bersyukur kerana ditemani isterinya, Nurhayati Azizan dan anak-anaknya, Luqman dan Ilyas yang selalu menjadi sumber inspirasi dan motivasi kepada penulis untuk menyiapkan penulisan buku ini. Kasih dan penghargaan penulis tidak pernah dilupakan kepada mereka semua.

Kepada semua pembaca yang budiman, selamat tinggal dan semoga dapat menghayati bacaan buku ini dengan baik.

PENGENALAN

Kebanyakan teknologi maklumat pengurusan penyenggaraan sedia ada sekarang masih menggunakan kaedah pemfailan dan lukisan manual. Dalam keadaan arus peredaran masa sekarang semua tugasan mahu disiapkan dengan cepat dan pantas. Kaedah pengurusan maklumat cara lama perlu ditambah upaya supaya dapat mengejar kepesatan pembangunan sekarang. Teknologi maklumat mengizinkan penggunanya mendapat maklumat yang disimpan dengan senang, cepat, lengkap dan tepat.

Satu pangkalan data yang bertindak untuk menyimpan segala lukisan yang berkaitan akan dibina dan ianya menjadi satu komponen utama dalam sesebuah teknologi maklumat. Masalah-masalah yang sering timbul sebelum ini seperti kehilangan rekod lukisan yang lama, kerosakan lukisan dan juga kehilangan serta mengambil masa yang lama untuk mendapat kembali lukisan akan berjaya dikurangkan. Maklumat yang ingin disampaikan oleh sesuatu badan atau jabatan kepada pengguna atau kakitangan akan menjadi lebih mudah dan berkesan. Begitu juga sekiranya ada masalah yang ingin diadukan oleh pengguna kepada pihak atasan sesuatu badan atau jabatan semuanya akan menjadi lebih efektif. Dengan teknologi yang wujud maklumat akan sentiasa berada di hujung jari dapat diperolehi dari mana-mana tempat sahaja dengan pantas. Internet yang menghubungkan berjuta-juta komputer di dunia ini akan menjadi alat penghubung di antara penyampai dan penerima maklumat.

Laporan teknikal ini membentangkan lukisan siap bina (as-built) menggunakan teknologi Pemodelan Maklumat Bangunan (BIM) untuk penyelenggaraan bangunan PTPTN di Kuala Lumpur. Kepentingan kajian ini secara amnya adalah dapat dijadikan asas dan petunjuk kepada usaha untuk menghasilkan satu lukisan siap bina (as-built) yang lebih berkualiti dalam mengurus dan mengemaskini maklumat rekabentuk bangunan serta mempunyai kelebihan dapat dicapai pada bila-bila masa sahaja melalui internet. Objektif kajian adalah untuk mengenalpasti aliran kerja yang dilaksanakan di dalam membangunkan satu lukisan siap bina (as-built) menggunakan teknologi BIM untuk digunapakai dalam penyelenggaraan bangunan. Perisian BIM yang digunakan dalam kajian ini adalah Autodesk Revit. Hasil daripada kajian ini membolehkan

lukisan siap bina (as-built) merekod maklumat spesifikasi dan data yang terlibat dalam kerja penyelarasan dan penyelenggaraan. Lukisan as-built yang dihasilkan boleh digunakan secara kolaborasi antara pasukan pembinaan ataupun di dalam sesebuah rangkaian berkomputer.

PENGENALAN PENERIMAAN ASET

1.1 Penyerahan dan penerimaan Aset

Sebagai seorang **BIM Modeller** untuk penyelenggaraan bangunan, penerimaan aset dari kontraktor untuk diserahkan kepada pihak pelanggan adalah tanggungjawap yang berat. Berat yang dimaksudkan ialah kita menerima sesuatu yang dibina oleh pihak lain(kontraktor) dan di serahkan apabila siap dan menjadi tanggungjawab kita pula menyerahkan aset ini kepada jabatan pelanggan. Semasa saya bertugas sebagai BIM Modeller, penyerahan sesuatu aset (bangunan) kepada jabatan pelanggan adalah perkara biasa. Dari pemerhatian saya, pelanggan mengharapkan sesuatu yang terbaik pada produk yang diserahkan kepadanya. Produk tersebut diharapkan tidak mempunyai cacat-celanya yang boleh menimbulkan rasa tidak hati pada pelanggan.

Tapi, untuk mencapai tahap kesempurnaan total, ini adalah mustahil. Namun,melalui prosedur-prosedur kerja JKR, ianya ada penambahbaikan kepada sistem penyerahan yang dilakukan sebelumnya.Ini bermaksud JKR prihatin dalam menjaga hati jabatan pelanggan dalam menzahirkan sesuatu produk yang dizahirkan.

Terma-terma dalam penerimaan sesuatu Aset

Sebagai penerima aset,kita perlulah maklum dengan terma-terma dalam penerimaan dan penyerahan sesuatu aset iaitu perkara-perkara seperti berikut:

i. **Pelanggan**

   Pelanggan dalam konteks JKR adalah semua kementerian/ jabatan/ agensi kerajaan/ badan berkanun yang menerima perkhidmatan yang diberikan oleh JKR.

ii. **Produk**

   Produk ialah hasil daripada perkhidmatan yang diberi, termasuk hasil diperingkat pemprosesan seperti lukisan, rekabentuk, dokumen tender, kontrak, komponen-komponen produk siap semasa pembinaan dan produk akhir.

iii. Produk Siap

Produk Siap ialah hasil daripada kerja pembinaan/ pemasangan bagaimana-mana bahagian/ komponen dari produk akhir semasa pembinaan.

iv. Produk akhir

Produk akhir dalam kontek JKR merupakan hasil dari perkhidmatan yang diberikan oleh JKR kepada Kementerian/Jabatan/Agensi Kerajaan seperti jalan, bangunan, binaan dan lain-lain.

v. Penyerahan

Penyerahan merupakan aktiviti memindah kuasa tanggungjawab/milik sesuatu produk dari JKR kepada pelanggan.

vi. **Pra Penyerahan**

Pra Penyerahan merupakan aktiviti yang dilakukan sebelum memindah kuasa tanggungjawab/milik sesuatu produk dari JKR kepada pelanggan.

vii. **Pos penyerahan**

Pos Penyerahan merupakan aktiviti yang dilakukan selepas memindah kuasa tanggungjawab/milik sesuatu produk dari JKR kepada pelanggan dalam TTK.

viii. Tempoh Tanggungan Kecacatan (TTK)

Tempoh Tanggungan Kecacatan adalah tempoh tanggungjawab kontraktor menyenggara atau membaiki kecacatan/kerosakan produk selepas pembinaan yang tetapkan dalam kontrak.

ix. Laporan Kecacatan/ Kerosakan

Laporan kecacatan/ Kerosakan adalah aduan/maklumbalas penemuan kecacatan/kerosakan produk semasa/ selepas pembinaan oleh pihak pelanggan kepada JKR.

Pihak pelanggan telah dimaklumkan dengan terma-terma ini yang ada kaitannya dengan penerimaan sesuatu aset.

1.2 Proses kerja penyerahan dan pos penyerahan/

Sebelum sesuatu aset boleh diterima ianya hendaklah melalui langkah-langkah yang berikut :-

1.2.1 Fasa 1

1. Mengadakan lawatan/pemeriksaan pra penyerahan bersama pihak pelanggan;
2. Jabatan Perlaksana akan menyediakan laporan hasil lawatan;
3. Menyediakan analisis laporan kecacatan kepada Pegawai Penguasa.
4. Pegawai Penguasa akan membuat keputusan samada produk ini sesuai diserahkan.Biasanya,kriteria yang diambil kira ialah,jenis-jenis kerja-kerja kecil yang masih tertangguh,tarikh tamat tempuh kontrak(kalau tidak,perlu menyediakan Perakuan Tempuh Lanjutan Masa (EOT);
5. Projek ini diserahkan kepada jabatan pelanggan.

1.2.2 Fasa 2

1. Selepas projek ini diserahkan,pemantauan masih lagi dilakukan yang melibatkan kerja-kerja pembaikkan kecil kerosakan.
2. Pembaikkan kecil ini dilakukan oleh Kontraktor Utama yang melaksanakan projek dalam Tempuh Tanggungan Kecacatan.Dalam phasa ini:
3. Segala aduan kerosakan di kemukakan oleh jabatan pelanggan untuk tujuan diperbaikki oleh Kontraktor Utama.
4. Tempoh pembaikan ini adalah 1 tahun 3 bulan 14 hari.
5. Setelah kerja-kerja siap membaikki kecacatan dalam TTK ini disempurnakan jabatan perlaksana akan mengeluarkan Perakuan Sijil Siap Baiki Kecacatan di keluarkan kepada kontraktor.
6. Ini juga melibatkan pelepasan bon/insuran Wang Jaminan Perlaksanaan (WJP). Untuk makluman: 50% WJP di lepaskan selepas keluarnya Sijil Perakuan Siap Kerja. Manakala lebihan 50% WJP dilepaskan setelah tamat Tempuh Tanggungan Kecacatan (TTK).

1.2.4 Pengurusan Aset Menyeluruh

Bagi Penerimaan Aset Menyeluruh penekanannya kepada pengurusan aset yang lebih komprehensif dan bersepadu supaya aset tersebut berada di dalam keadaan yang sempurna, selamat digunakan serta dapat menjaminkan jangka hayat aset yang lebih lama.

Struktur dokumen pengurusan aset kerajaan terdiri dari 4 peringkat dokumen utama.Dokumen-dokumen ini ialah:-

1. **Dokumen Dasar**
   Dokumen ini menggariskan Dasar dan Strategi Pengurusan Aset Kerajaan.
2. **Dokumen Manual**
   Menjelaskan Konsep Amalan dan Tanggungjawab PAM (Pengurusan Aset Menyeluruh).
3. **Dokumen Tatacara Pengurusan**
   Dokumen ini menjelaskan tatacara operasi pengurusan aset kerajaan mengikut PAM dan terbahagi kepada Aset Tanah, Aset Bangunan, Aset Infrastruktur, Aset Alih dan Aset hidup.
4. **Dokumen Sokongan**
   Dokumen ini merupakan dokumen sokongan yang menjadi rujukan dalam operasi pengurusan Aset Kerajaan.

1.3 Proses Penerimaan Aset dalam Pengurusan Aset Menyeluruh

Bagi Penerimaan Pengurusan Aset Menyeluruh ianya juga mempunyai perkara-perkara yang berikut:-

1. Skop dan objektif penerimaan aset.
2. Peringkat-peringkat proses/aktiviti dan dokumentasi pemerimaan aset.
3. Peringkat perakuan dan persijilan yang terlibat bagi penerimaan aset serta pendaftaran aset;
4. Tanggungjawap,kuasa dan pelan komunikasi antara pegawai yang terlibat dalam proses penerimaan aset;
5. Keperluan sumber (kakitangan,kewangan,peralatan dan bahan)

1.3.1 Pelan Operasi dan Penyelenggaraan Aset dalam Pengurusan Aset Menyeluruh.

- Pengurusan Fasiliti
- Pengurusan Waktu Operasi
- Pengurusan Keselamatan
- Pengurusan Kebersihan
- Pengurusan Ruang
- Pengurusan Majlis
- Pengurusan Tenaga
- Pengurusan Sisa Buangan
- Pengurusan Sumber
- Pengurusan Krisis dan Bencana
- Pengurusan Prestasi

JKR telah mempraktikan penggunaan borang-borang tertentu dalam proses penyerahan aset. JKR telah pun melaksanakan peraturan-peraturan di dalam SPK bagi penyerahan dan penerimaan sesuatu Aset.

Peraturan-peraturan di dalam SPK itu pula memastikan proses-proses yang dikehendaki mematuhi carta alir yang disediakan.

Begitu juga dengan senarai-senarai kerosakan atau kecacatan bangunan selepas penerimaan didokumenkan bagi memudahkan tindakan.

Saya berpendapat,dalam Pengurusan Aset Menyeluruh ianya banyak menyentuh kepada dasar-dasarnya yang perlu dipatuhi.

Penguatkuasaan atau pemakaian peraturannya dan bagaimana mahu dilaksanakan sewaktu penyerahan dan penerimaan sesuatu aset masih lagi dalam perancangan ataupun berkemungkinan diadaptasikan dengan Borang-Borang SPK JKR sedia ada.

Agensi Pengurusan Aset ini sebuah agensi yang besar dan mengawal agensi-agensi dibawahnya.

Ia merupakan organisasi yang besar dalam melaksanakan kerja-kerja dan tanggungjawapnya yang telah ditentukan.Ianya memerlukan kos sumber manusia yang besar dan pada masa yang sama penyelenggaraaan aset juga memerlukan kos yang besar juga.

Agensi Pengurusan Aset Menyeluruh telah mensyaratkan setiap kakitangan yang terlibat dengan pengurusan aset ini dihantar berkursus untuk mempertingkatkan kompetensinya di dalam penyeliaan aset di bawah tanggungjawapnya.

Manakala, mengikut pengalaman saya, proses penerimaan dan penyerahan aset yang dilakukan di peringkat daerah masih lagi tanggungjawap wakil Pegawai Penguasa yang berkenaan hinggalah sesuatu aset tamat melalui Tempuh Tanggungan Kecacatan dan Sijil Membaikki Tempuh Tanggungan Kecacatan dikeluarkan kepada kontraktor berkenaan.

1.4 Model Umum Projek

Nama Projek: **Untuk mencadangkan kaedah menguatkan sebahagian papak dan rasuk pada bangunan tingkat 9, blok D, menara pejabat, lot P13 dan 88 jalan Yap Kwan Seng, Seksyen 44, Wilayah Persekutuan Kuala Lumpur.**

1.4.1 Isu

Setelah menerima projek ini, penggunaan bangunan ini terbantut kerana berlakunya beberapa kekurangan dan kelemahan.Kekurangan dan kelemahan perlu diperbaikki bagi membolehkan ianya digunakan dengan lebih berkesan.

- **Kekurangaan sokongan kekuatan pada lantai.**

  Pengubahsuaian bangunan adalah untuk menyediakan ruang bilik yang lebih selesa untuk bangunan pejabat PTPTN ini.Walaubagaimanapun berlaku gangguan sokongan kekuatan komponen pada bangunan ini.Kontraktor utama telah dimaklumkan untuk menyiasat dan membaiki kelemahan ini kerana aset ini adalah masih di dalam Tempuh Tanggungan Kecacatan.

- **Kekurangaan sokongan kekuatan pada bahagian rasuk.**

  Di dapati kerja-kerja rasuk renggang dan tidak ditutup rapat pada bahagian tetulang yang sediakan. Ini menyebabkan terdapat ruang yang renggang dan berada dalam keadaan tidak stabil dan merbahayakan kepada keselamatan kakitangan dalam bangunan.

  Mesyuarat untuk membincangkan masalah ini telah diadakan.Bagi mengukuhkan bukti kerosakkan ini, pihak saya telah menggunakan ‘slide; bagi memberikan gambaran yang jelas tentang kekurangan yang dimaksudkan. Ini pula bagi memudahkan pihak kontraktor membaikki kerosakan-kerosakan yang dinyatakan.Manakala itu, bagi menentukan kekurangan ini telah dilakukan, senarai semakan telah disediakan.

  Pemeriksaan tapak telah diadakan pada setiap mesyuarat bagi memastikan kerosakan tersebut telah sempurna diperbaikki oleh pihak kontraktor.

1.4.2 Cadangan

Setelah melalui penerimaan aset ini, masalah yang utama adalah kekurangan yang berlaku setelah aset di terima. Kerosakan ini boleh menjejaskan jangka hayat bangunan ini.

Kekurangan yang berlaku boleh dielakkan sekiranya pihak penyelia projek memantau aktiviti projek dengan lebih berkesan.Saya ingin mencadangkan beberapa pendekatan yang boleh diambil bagi mengelakkan perkara ini berlaku pada masa depan. Antara cadangan-cadangan saya ini adalah seperti berikut:-

1. Turun padang bagi meninjau aktiviti-aktiviti pembinaan yang dilaksanakan oleh pihak kontraktor.
2. Spesifikasi kerja dan lukisan hendaklah dijadikan bahan

rujukan teras bagi memantau aktiviti-aktiviti pembinaan di tapakbina.

3. Bahan-bahan yang digunakan hendaklah dari jenis yang berkualiti.
4. Sekiranya, projek tersebut ada konsultan, adalah lebih baik turut melibatkan mereka dalam mengawasi projek ini supaya lukisan senibina atau struktur yang disediakan oleh mereka boleh dipertanggungjawabkan bersama.Ini bagi menggelakkan segala kesulitan lukisan tersebut ditanggung oleh pihak BIM Modeller yang berada di tapak.
    - Dalam ujian larian dan pertauliahan (testing &commisioning) sila pastikan ianya dilakukan oleh kontraktor yang yang kompeten.
    - Pasti ada saksi-saksi (witnesses) hadir sama ke tapakbina sewaktu ujian-ujian tersebut dilaksanakan di tapak.

1.4.3 PENYELESAIAN

Bil	Keterangan Kerosakan	Tindakan
1	Kekurangaan sokongan kekuatan pada lantai	Menghubungi pihak Forensik JKR untuk mengenalpasti punca kerosakan. Oleh kerana di dalam tempuh tanggungan kecacatan,pihak kontraktor utama telah dikehendaki melakukan baikpulih kerja-kerja ini.
2	Kekurangaan sokongan kekuatan pada rasuk	Rasuk ini di perbetulkan dengan meletakkan FRP bagi mengikatkemas pada bahagian tetulangnya.

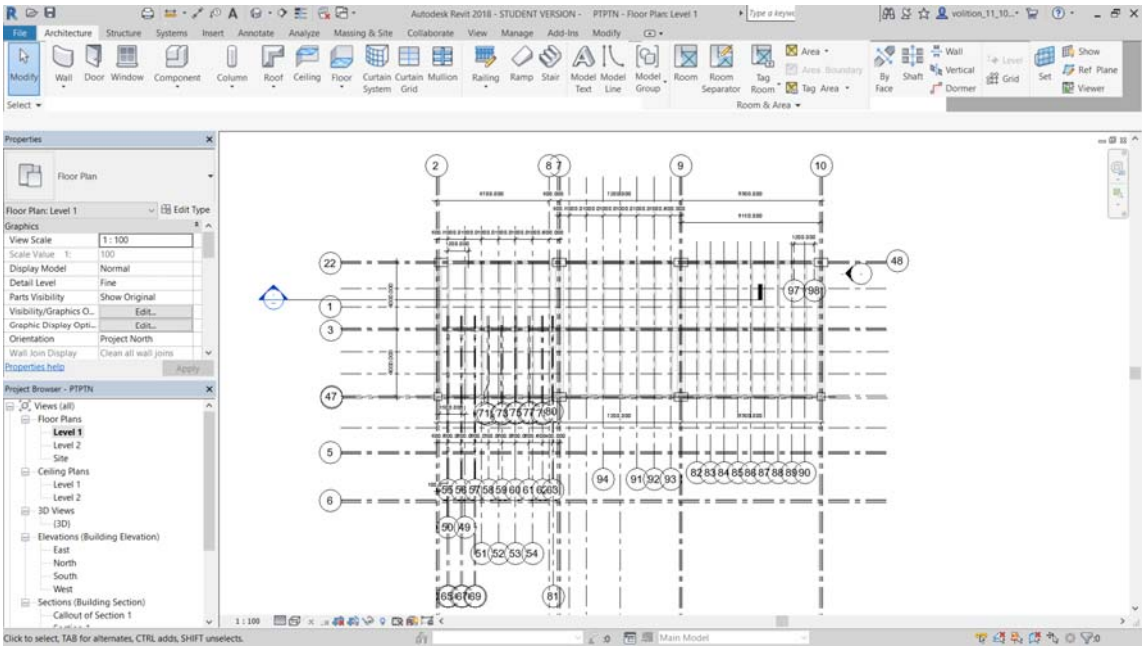
1.4.4 RUMUSAN

Penerimaan Aset melibatkan penyerahan sebuah bangunan sekolah yang telah siap dan proses penyerahan dan penerimaannya melalui berbagai prosedur-prosedur bagi mewujudkan ketelusan dan integriti dalam penyerahannya itu.

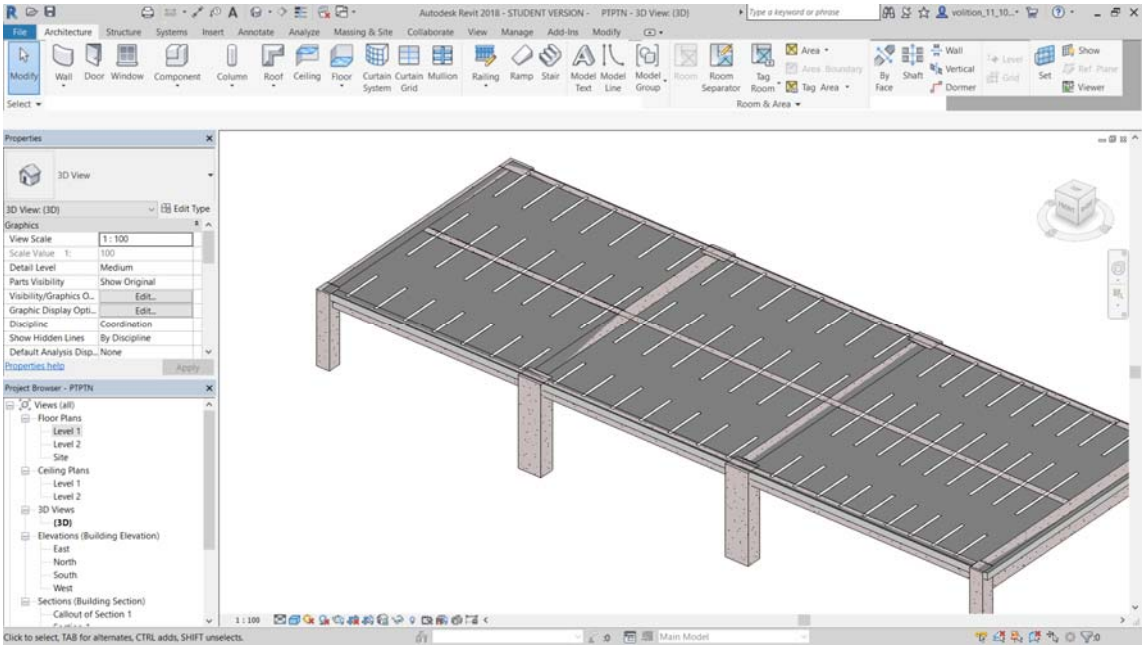
Lukisan-lukisan yang digunapakai semasa kerja-kerja operasi dan penyenggaraan adalah usaha yang bersungguh-sungguh dari pihak saya bahawa setiap kekurangan/kelemahan yang berlaku akan diperbaiki oleh pihak kontraktor dalam Tempoh Tanggungan Kecacatan yang diberikan.

Saya melihat dalam Pengurusan Aset Menyeluruh, lebih banyak perkara dibincangkan dan dikupas dengan lebih ‘details’ bagi tujuan memantapkan lagi prosedur-prosedur yang kita amalkan di dalam Jabatan Kerja Raya (JKR) sebelum ini.

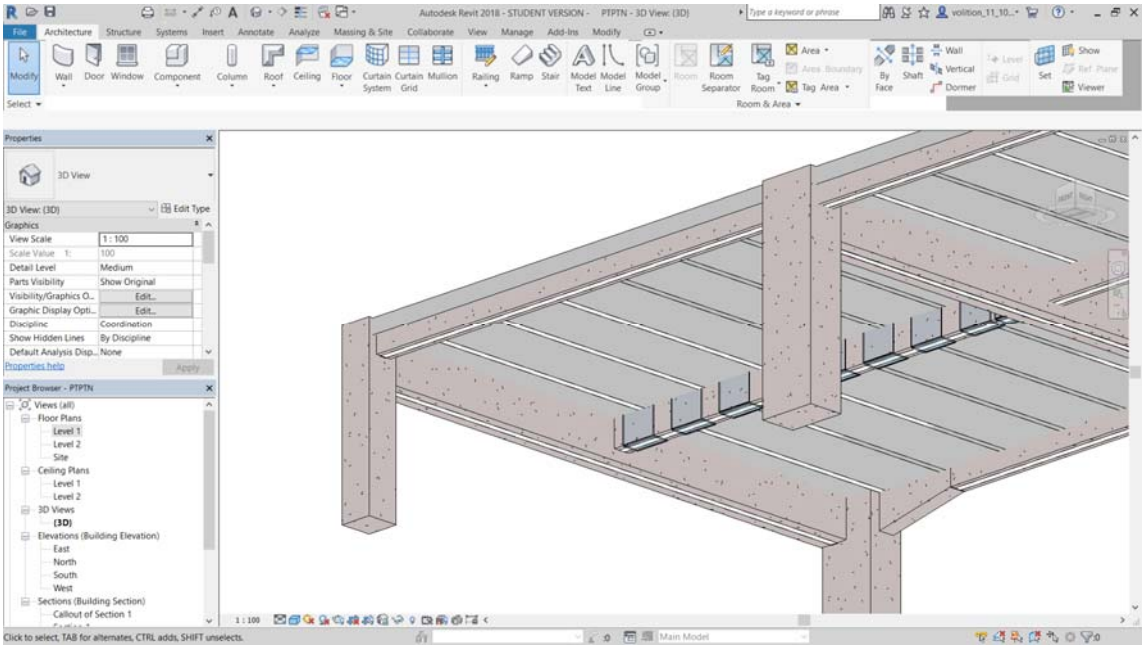
APLIKASI PERISIAN BIM (AUTODESK REVIT) DALAM LUKSAN SIAP BINA



Rajah 1.1: Lukisan siap bina yang telah siap.



Rajah 1.2: Lantai bangunan yang telah dibaiki.



Rajah 1.3: Rasuk bangunan yang telah dibaiki.

Rujukan.

1. Prosedur Penyerahan dan Pos Penyerahan [JKR.PK(0).05]
2. Manual Pengurusan Aset Menyeluruh -MAMPU
3. Zainal Abidin Mohamed(2002): Pengurusan Strategik,Edisi Kedua,
   Siri Pengurusan dan Pentadbiran Utusan.
4. Salihudin Hassim dan Mohd.Razali Abdul Kadir (2001): Pengurusan Dalam Kerjaya
   Kejuruteraan: Universiti Putra Malaysia,Serdang.

2.1 Analisis Lantai

RESTRAINED SLAB DESIGN

CASE 1 ===> INTERIOR PANELS

Short span, lx =	4000	mm	Neg.	sx =	0.063	
Long span, ly =	9000	mm	Pos.	sx =	0.048	
			Neg.	sy =	0.032	
ly/lx = 2.25			Pos.	sy =	0.024	

Slab thickness =	125	mm	fy =	460	N/mm^2		
Concrete cover =	20	mm	fcu =	50	N/mm^2		
Top bar size =	10	mm					
Bot. bar size =	10	mm	Effective depth, d =	100	mm	Both span	Top reinf.
			Effective depth, d =	100	mm	Short span	Bottom reinf.
			Effective depth, d =	90	mm	Long span	Bottom reinf.

LOADING (1 metre strip)

Self weight	=	0	kN/m
Finishes	=	0	kN/m
Live load	=	2.5	kN/m
n_{ult}	=	4	kN/m

BENDING

Short span	Neg.	M =	$sx.n_{ult}.lx^2$	=	4.032	kNm
	Pos.	M =	$sx.n_{ult}.lx^2$	=	3.072	kNm
Long span	Neg.	M =	$sy.n_{ult}.lx^2$	=	2.048	kNm
	Pos.	M =	$sy.n_{ult}.lx^2$	=	1.536	kNm

RESTRAINED SLAB DESIGN

CASE 2 === ONE SHORT EDGE DISCONTINUOUS

Short span, lx =	4000	mm		Neg.	sx =	0.067
Long span, ly =	9000	mm		Pos.	sx =	0.050
				Neg.	sy =	0.037
ly/lx = 2.25				Pos.	sy =	0.028

Slab thickness =	125	mm	fy =	460	N/mm^2			
Concrete cover =	20	mm	fcu =	25	N/mm^2			
Top bar size =	10	mm						
Bot. bar size =	10	mm	Effective depth, d =	100	mm	Both span	Top reinf.	
			Effective depth, d =	100	mm	Short span	Bottom reinf.	
			Effective depth, d =	90	mm	Long span	Bottom reinf.	

LOADING (1 metre strip)

Self weight	=	0	kN/m
Finishes	=	0.0	kN/m
Live load	=	2.5	kN/m
n_{ult}	=	4	kN/m

BENDING

Short span	Neg.	M =	$sx.n_{ult}.lx^2$	=	4.288	kNm
	Pos.	M =	$sx.n_{ult}.lx^2$	=	3.2	kNm
Long span	Neg.	M =	$sy.n_{ult}.lx^2$	=	2.368	kNm
	Pos.	M =	$sy.n_{ult}.lx^2$	=	1.792	kNm

RESTRAINED SLAB DESIGN

PANEL TYPE: S2 FLOOR

CASE 4 ===> TWO ADJACENT EDGES DISCONTINUOUS

Short span, lx =	4000	mm	Neg.	sx =	0.093
Long span, ly =	9000	mm	Pos.	sx =	0.070
			Neg.	sy =	0.045
ly/lx = 2.25			Pos.	sy =	0.034

Slab thickness =	125	mm	fy =	460	N/mm^2
Concrete cover =	20	mm	fcu =	25	N/mm^2
Top bar size =	10	mm			
Bot. bar size =	10	mm			

Effective depth, d =	100	mm	Both span	Top reinf.
Effective depth, d =	100	mm	Short span	Bottom reinf.
Effective depth, d =	90	mm	Long span	Bottom reinf.

LOADING (1 metre strip)

Self weight	=	0	kN/m
Finishes	=	0	kN/m
Live load	=	2.5	kN/m
n_{ult}	=	4	kN/m

BENDING

Short span	Neg.	M =	$sx.n_{ult}.lx^2$ =	5.952	kNm
	Pos.	M =	$sx.n_{ult}.lx^2$ =	4.48	kNm
Long span	Neg.	M =	$sy.n_{ult}.lx^2$ =	2.88	kNm
	Pos.	M =	$sy.n_{ult}.lx^2$ =	2.176	kNm

2.2 Analisis Rasuk

FRP DESIGN FOR STRENGTHENING- STRUCTURAL ANALYSIS

Design Information,

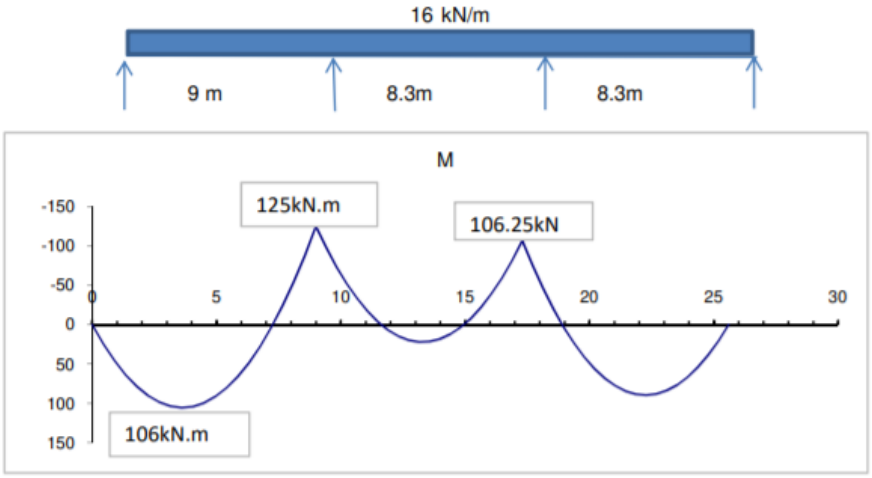
Current Usage- Office Assumed Live Load- 2.0 kN/m^2

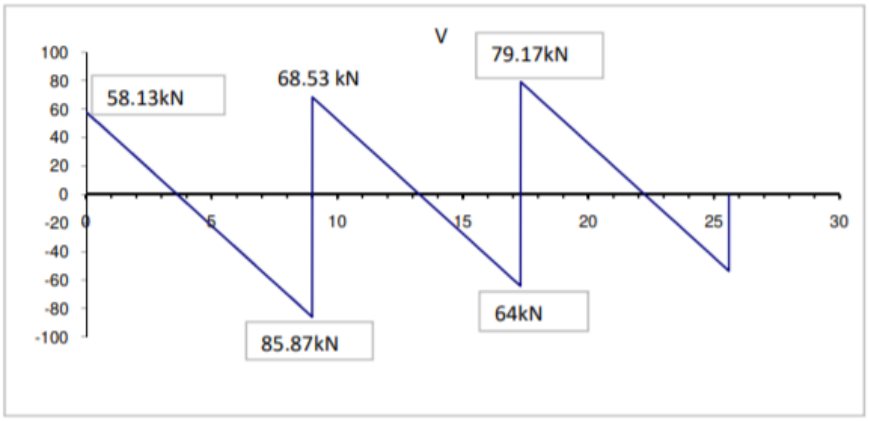
Design For Data Centre- Increase Live Load to 4.5 kN/m^2

Beam B1-B4 (230x600)

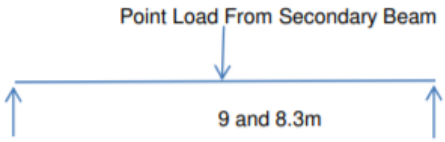
Loading From Slab = 2.5 kN/m^2

ULT. UDL on Beam = 16 kN/m





Beam A3-C3 / A2-C2 (460X600 /460X750)



Reaction 1 =	58.13178 kN	L (m) =	8	Ult.Moment PL/4 =	116.2636 kN.m
Reaction 2 =	154.4655 kN	L (m) =	8	Ult.Moment PL/4 =	308.931 kN.m
Reaction 3=	143.4433 kN	L (m) =	8	Ult.Moment PL/4 =	286.8865 kN.m
Reaction 4=	53.55946 kN	L (m) =	8	Ult.Moment PL/4 =	107.1189 kN.m

2.3 Reka Bentuk Kekuatan Untuk Lantai

FRP DESIGN FOR STRENGTHENING- CONCRETE SLAB WITH EMBEDDED FRP (10mm maximum)

Geometric and material properties

Concrete:

b =	1000	mm
h =	125	mm
f'_c =	25	MPa

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	115	mm/mm

(max 10 mm FRP inserted inside concrete)

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 24.29577465 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 267.0497416 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **267.0497416**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.00159155

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.6199385

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.735333155	
C= εc/ εfe+εc * df =	14.3085279	mm
Cc =α1β1fc'Cb =	221.7601831	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.76**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.00159155

Final Result,

εc/ε'c	0.8753525
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon'c^2$ =	0.6199385
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.735333155

The nominal moment calculated for understrength member

$$M_n = A_s f_y \left(d_s - \beta_1 \frac{c}{2} \right) + A_f E_f \varepsilon_{fe} \left(d_f - \frac{\beta_1 c}{2} \right)$$

Mn = 24.3357722 kN.m (About **440.79 %** increament)

Increased moment due to load increament (2.5 kN/m^2)

Hogging moment	6 kN.m	(From Slab analysis)
Sagging moment	4.5 kN.m	(From Slab analysis)

Applied Number of plate per 1m width = 1

FRP DESIGN FOR STRENGTHENING- CONCRETE SLAB WITH EXPOSED FRP

Geometric and material properties

Concrete:

b =	1000	mm
h =	125	mm
f'_c =	25	MPa

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	125	mm/mm

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 26.4084507 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 290.2714583 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **290.2714583**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.0015045

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.599236708

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.730146949	
C= εc/ εfe+εc * df =	14.80282577	mm
Cc =α1β1fc'Cb =	221.7599146	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.76**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.0015045

Final Result,

εc/ε'c	0.827475
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon'c^2$ =	0.599236708
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.730146949

The nominal moment calculated for understrength member

$$M_n = A_s f_y \left(d_s - \beta_1 \frac{c}{2} \right) + A_f E_f \varepsilon_{fe} \left(d_f - \frac{\beta_1 c}{2} \right)$$

Mn = 26.52158256 kN.m (About **489.37 %** increament)

Increased moment due to load increament (2.5 kN/m^2)

Hogging moment	6 kN.m	(From Slab analysis)
Sagging moment	4.5 kN.m	(From Slab analysis)

Applied Number of plate per 1m width = 1

2.4 Reka Bentuk Kekuatan Untuk Rasuk

FRP DESIGN FOR STRENGTHENING- PRIMARY BEAM 230X460 (SAGGING AREA)

Geometric and material properties

Concrete:

b =	230	mm
h =	125	mm
f'_c =	25	MPa
d =	600	mm

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	600	mm/mm
fyp =	2800	MPa

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 126.7605634 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/E f\varepsilon fe$ = 320.45969 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **320.45969**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.00141

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.57503325

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.724769611	
C= εc/ εfe+εc * df =	67.08961142	mm
Cc =α1β1fc'Cb =	221.8278545	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.83**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.00141

Final Result,

εc/ε'c	0.7755
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon'c^2$ =	0.57503325
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.724769611

The nominal moment calculated for understrength member

$$M_n = A_s f_y \left(d_s - \beta_1 \frac{c}{2} \right) + A_f E_f \varepsilon_{fe} \left(d_f - \frac{\beta_1 c}{2} \right)$$

Mn = 127.6645142 kN.m (About **20.44 %** increament)
(For 1 layer)

Increased moment due to load increament (2.5 kN/m^2)

Max Ult Moment= 106 kN.m
(From Structural Analysis)

Applied Number of FRP = 1

Recalculated Mn = 127.6645142 kN.m (About **20.44 %** increament)

SHEAR DESIGN

E_c = 23500 MPa

E_f = 165000 MPa

$n_f = E_f/E_c$ = 7.021276596

$p_f = A_f/bd$ = 0.000869565

$$K = \sqrt{2\rho_f n_f + (\rho_f n_f)^2} - \rho_f n_f$$

k= 0.104566094

Shear Demand = 85 kN (From structural analysis)

Concrete shear contribution

$$V_{cf} = \frac{2}{5}\sqrt{f'_c}\, b_w kd$$

V_{cf} = 28.86024199 kN < 85 kN

$0.8f_{yp} = f_{fu}$ = 2240 MPa

Assumed allowable bend radius rb/db =3.0

$$f_{fb} = \left(0.05\frac{r_b}{d_b} + 0.3\right) f_{fu}$$

f_{fb} = 1008 Mpa > 660 Mpa ($0.004E_f$)

Use lower value as f_{fv} (Limit of Design Stress)

$$s = \frac{0.75A_{fv}f_{fv}d}{V_u - 0.75V_{cf}}$$

s= 1335.961812 mm

$$s = \frac{A_{fv}f_{fv}}{0.35b_w}$$

min s = 1967.701863 mm

Therefore stirrup at every 1500mm

U-shape stirrup.

FRP DESIGN FOR STRENGTHENING- PRIMARY BEAM 230X460 (HOGGING AREA)

Geometric and material properties

Concrete:

b =	230	mm
h =	125	mm
f'_c =	25	MPa
d =	600	mm

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	600	mm/mm

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 126.7605634 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 320.45969 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **320.45969**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.00141

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.57503325

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.724769611	
C= εc/ εfe+εc * df =	67.08961142	mm
Cc =α1β1fc'Cb =	221.8278545	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.83**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.00141

Final Result,

εc/ε'c	0.7755
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon'c^2$ =	0.57503325
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.724769611

The nominal moment calculated for understrength member

$$M_n = A_s f_y\left(d_s - \beta_1 \frac{c}{2}\right) + A_f E_f \varepsilon_{fe}\left(d_f - \frac{\beta_1 c}{2}\right)$$

Mn = 127.6645142 kN.m (About **2.13 %** increament)
(For 1 layer)

Increased moment due to load increament (2.5 kN/m^2)

Max Ult Moment= 125 kN.m
(From Structural Analysis)

Applied Number of FRP = 1

Recalculated Mn = 127.6645142 kN.m (About **2.13 %** increament)

FRP DESIGN FOR STRENGTHENING- PRIMARY BEAM 460X600

Geometric and material properties

Concrete:

b =	460	mm
h =	125	mm
f'c =	25	MPa
d =	750	mm

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	750	mm/mm
fyp =	2800	MPa

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, εf = εfe = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 158.4507042 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 801.1492249 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **801.1492249**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.000812

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.380116147

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.695817342	
C= εc/ εfe+εc * df =	50.6993007	mm
Cc =α1β1fc'Cb =	221.6236624	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.62**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.000812

Final Result,

εc/ε'c	0.4466
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon'c^2$ =	0.380116147
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.695817342

The nominal moment calculated for understrength member

$$M_n = A_s f_y \left(d_s - \beta_1 \frac{c}{2} \right) + A_f E_f \varepsilon_{fe} \left(d_f - \frac{\beta_1 c}{2} \right)$$

Mn = 162.4084361 kN.m (About **-43.41 %** increament)
(For 1 layer)

Increased moment due to load increament (2.5 kN/m^2)

Ult.Moment = 287 kN.m (From Analysis)

Applied Number of FRP = 2 layer

Recalculated Mn = 324.8168721 kN.m (About **13.18 %** increament)

SHEAR DESIGN

E_c = 23500 MPa

E_f = 165000 MPa

$n_f=E_f/E_c$= 7.021276596

$p_f=A_f/bd$= 0.000347826

$$K = \sqrt{2\rho_f n_f + (\rho_f n_f)^2} - \rho_f n_f$$

k= 0.067488715

Shear Demand = 77.25 kN (From structural analysis)

Concrete shear contribution

$$V_{cf} = \frac{2}{5}\sqrt{f'_c}\, b_w k d$$

V_{cf} = 46.56721369 kN < 77.25 kN

$0.8f_{yp}=f_{fu}$= 2240 MPa

Assumed allowable bend radius rb/db =3.0

$$f_{fb} = \left(0.05\frac{r_b}{d_b} + 0.3\right) f_{fu}$$

f_{fb}= 1008 Mpa > 660 Mpa ($0.004E_f$)

Use lower value as f_{fv} (Limit of Design Stress)

$$s = \frac{0.75 A_{fv} f_{fv} d}{V_u - 0.75 V_{cf}}$$

s= 2105.159213 mm

$$s = \frac{A_{fv} f_{fv}}{0.35 b_w}$$

min s = 983.8509317 mm

Therefore stirrup at every 900mm

FRP DESIGN FOR STRENGTHENING- PRIMARY BEAM 230X460

Geometric and material properties

Concrete:

b =	230	mm
h =	125	mm
f'_c =	25	MPa
d =	460	mm

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	460	mm/mm
fyp=	2800	MPa

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 97.18309859 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 245.6857623 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **245.6857623**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.00168625

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.640724061

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.741247248	
C= εc/ εfe+εc * df =	60.19400524	mm
Cc =α1β1fc'Cb =	221.7645481	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.76**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.00168625

Final Result,

εc/ε'c	0.9274375
$\alpha1\beta = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ =	0.640724061
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.741247248

The nominal moment calculated for understrength member

$$M_n = A_s f_y \left(d_s - \beta_1 \frac{c}{2} \right) + A_f E_f \varepsilon_{fe} \left(d_f - \frac{\beta_1 c}{2} \right)$$

Mn = 97.06228511 kN.m (About **19.83 %** increament)
(For 1 layer)

Increased moment due to load increament (2.5 kN/m^2)

Unifrom load $wL^2/8$ = 81 kN.m w = 8 kN/m
L = 9 m

Applied Number of FRP = 1

Recalculated Mn = 97.06228511 kN.m (About **19.83 %** increament)

SHEAR DESIGN

E_c = 23500 MPa
E_f = 165000 MPa
$n_f = E_f/E_c$ = 7.021276596
$p_f = A_f/bd$ = 0.001134216

$$K = \sqrt{2\rho_f n_f + (\rho_f n_f)^2} - \rho_f n_f$$

k= 0.118490703

Shear Demand = 22.5 kN (From structural analysis)

Concrete shear contribution

$$V_{cf} = \frac{2}{5}\sqrt{f'_c}\, b_w k d$$

V_{cf} = 25.07263277 kN < 22.5 kN

$0.8f_{fyp} = f_{fu}$ = 2240 MPa

Assumed allowable bend radius rb/db =3.0

$$f_{fb} = \left(0.05\frac{r_b}{d_b} + 0.3\right) f_{fu}$$

f_{fb}= 1008 Mpa > 660 Mpa ($0.004E_f$)
Use lower value as f_{fv} (Limit of Design Stress)

$$s = \frac{0.75 A_{fv} f_{fv} d}{V_u - 0.75 V_{cf}}$$

s= 52121.83222 mm

$$s = \frac{A_{fv} f_{fv}}{0.35 b_w}$$

min s = 1967.701863 mm

Therefore stirrup at every 1900mm

FRP DESIGN FOR STRENGTHENING -PRIMARY BEAM 400X750

Geometric and material properties

Concrete:

b =	400	mm
h =	125	mm
f'_c =	25	MPa
d =	750	mm

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2
FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	750	mm/mm
fyp =	2800	MPa

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112
Concrete strain, εcu = 0.003
Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 158.4507042 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 696.6514999 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **696.6514999**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.00088

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.405914667

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.69872814	
C= εc/ εfe+εc * df =	54.63576159	mm
Cc =α1β1fc'Cb =	221.7745695	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.77**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.00088

Final Result,

εc/ε'c	0.484
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon'c^2$ =	0.405914667
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.69872814

The nominal moment calculated for understrength member

$$M_n = A_s f_y \left(d_s - \beta_1 \frac{c}{2} \right) + A_f E_f \varepsilon_{fe} \left(d_f - \frac{\beta_1 c}{2} \right)$$

Mn = 162.09 kN.m (About **39.73 %** increament)

Increased moment due to load increament (2.5 kN/m^2)

Ult.Moment = 116 kN.m

Applied Number of FRP= 1 layer

Recalculated Mn = 162.09 kN.m (About **39.73 %** increament)

SHEAR DESIGN

E_c = 23500 MPa
E_f = 165000 MPa
$n_f = E_f/E_c$ = 7.021276596
$p_f = A_f/bd$ = 0.0004

$$K = \sqrt{2\rho_f n_f + (\rho_f n_f)^2} - \rho_f n_f$$

k= 0.072190883

Shear Demand = 29.065 kN (From structural analysis)

Concrete shear contribution

$$V_{cf} = \frac{2}{5}\sqrt{f'_c}\, b_w k d$$

V_{cf} = 43.31452965 kN > 29.065 kN

$0.8 f_{yp} = f_{fu}$ = 2100 MPa

Assumed allowable bend radius rb/db =3.0

$$f_{fb} = \left(0.05\frac{r_b}{d_b} + 0.3\right) f_{fu}$$

f_{fb} = 945 Mpa > 660 Mpa ($0.004E_f$)
Use lower value as f_{fv} (Limit of Design Stress)

$$s = \frac{0.75 A_{fv} f_{fv} d}{V_u - 0.75 V_{cf}}$$

s= -13025.72734 mm

$$s = \frac{A_{fv} f_{fv}}{0.35 b_w}$$

min s = 1131.428571 mm

Therefore stirrup at every 1000 mm

FRP DESIGN FOR STRENGTHENING- PRIMARY BEAM 460X600

Geometric and material properties

Concrete:

b =	460	mm
h =	125	mm
f'_c =	25	MPa
d =	600	mm

Steel:

A_s =	0	mm^2
E_s =	0	MPa
f_{sy} =	0	MPa
d_s =	0	mm^2

(Assumed no additional Rebar)

Sika carboDur Plates, width=100 mm, Thk=1.2mm, Cross section, 120 mm^2

FRP (Refer to manufacture details):

A_f =	120	mm^2
E_f =	165000	MPa
ε_{frpu} =	0.016	mm/mm
d_f =	600	mm/mm
fyp =	2800	MPa

Determine nominal moment of the unstrengthed member

$\alpha_1 = 0.85-0.0015\ fc$ = 0.8125

$\beta_1 = 0.97-0.0035fc$ = 0.8825

$\beta_{1c} = Asfy/\alpha 1fcb$ = 0 mm

$M_n = Asfy(ds-\beta 1c/2)$ = 0 kN.m

Determine failure mode section

Effective FRP strain, $\varepsilon f = \varepsilon fe$ = 0.0112

Concrete strain, εcu = 0.003

Initial starin, εbi = 0

$C_b = (\varepsilon cu/\varepsilon fe+\varepsilon bi+\varepsilon cu)df$ = 126.7605634 mm

$A_{f,b} = (\alpha 1fcbCb-Asfy)/Ef\varepsilon fe$ = 640.9193799 mm2

Af=Afb - Balanced failure
Af<Afb -FRP failure
Af>Afb -Concrete failure

120 < **640.9193799**

OK to proceed

Determine nominal moment of strengthed member

Trial ε_c = 0.00092348

$\varepsilon'c = 2f'c/(5500)(f'c)^{1/2}$ = 0.001818182

$\alpha_1\beta_1 = \varepsilon c/\varepsilon'c - \varepsilon c^2/3\varepsilon'c^2$ = 0.42192179

β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.700635131	
C= εc/ εfe+εc * df =	45.70370884	mm
Cc =α1β1fc'Cb =	221.7589921	kN
Ts= Asfy =	0	kN
Tf = AfEfεfe =	221.76	kN
Tf = AfEfεfrp =	316.8	kN
Cc =	**221.76**	kN
Ts+Tf =	**221.76**	kN

Choose ε_c = 0.00092348

Final Result,

εc/ε'c	0.507914
α1β= εc/ε'c - $\varepsilon c^2/3\varepsilon' c^2$ =	0.42192179
β1= (4-(εc/ε'c)) / (6-(2εc/ε'c)) =	0.700635131

The nominal moment calculated for understrength member

$$M_n = A_s f_y\left(d_s - \beta_1 \frac{c}{2}\right) + A_f E_f \varepsilon_{fe}\left(d_f - \frac{\beta_1 c}{2}\right)$$

Mn = 129.5054423 kN.m (About **-58.09 %** increament)
(For 1 layer)

Increased moment due to load increament (2.5 kN/m^2)

Ult.Moment = 309 kN.m (From Analysis)

Applied Number of FRP = 3 layer

Recalculated Mn = 388.516327 kN.m (About **25.73 %** increament)

SHEAR DESIGN

E_c = 23500 MPa

E_f = 165000 MPa

$n_f=E_f/E_c=$ 7.021276596

$p_f=A_f/bd=$ 0.000434783

$$K=\sqrt{2\rho_f n_f+(\rho_f n_f)^2}-\rho_f n_f$$

k= 0.075144311

Shear Demand = 77.25 kN (From structural analysis)

Concrete shear contribution

$$V_{cf}=\frac{2}{5}\sqrt{f'_c}\,b_w kd$$

V_{cf} = 41.47965969 kN < 77.25 kN

$0.8f_{fyp}=f_{fu}=$ 2240 MPa

Assumed allowable bend radius rb/db =3.0

$$f_{fb}=\left(0.05\frac{r_b}{d_b}+0.3\right)f_{fu}$$

$f_{fb}=$ 1008 Mpa > 660 Mpa ($0.004E_f$)

Use lower value as f_{fv} (Limit of Design Stress)

$$s=\frac{0.75A_{fv}f_{fv}d}{V_u-0.75V_{cf}}$$

s= 1923.781757 mm

$$s=\frac{A_{fv}f_{fv}}{0.35b_w}$$

min s = 983.8509317 mm

Therefore FRP stirrup at every 900mm

U-shape stirrup.

LAMPIRAN

Construction

Sika CarboDur® Plates

Pultruded carbon fiber plates for structural strengthening

System Description

Sika CarboDur® plates are pultruded carbon fiber reinforced polymer (CFRP) laminates designed for strengthening concrete, timber and masonry structures.

Sika CarboDur® plates are bonded onto the structure as external reinforcement using Sikadur®-30 for normal - or Sikadur®-30 LP epoxy resin for elevated application temperatures (for details on the adhesive see the relevant Product Data Sheet).

Uses

To strengthen structures for:

Load increase:
- Increasing the capacity of floor slabs and beams
- Increasing the capacity of bridges to accommodate increase axle loads
- Installation of heavier machinery
- Stabilising vibrating structures
- Changes of building use

Damage to structural elements:
- Deterioration of original construction materials
- Steel reinforcement corrosion
- Vehicle impact
- Fire
- Earthquakes

Service improvements:
- Reduced deflection
- Stress reduction in steel reinforcement
- Crack width reduction
- Reduced fatigue

Change in structural system:
- Removal of walls or columns
- Removal of slab sections for openings

Change of specification:
- Earthquakes
- Changed design philosophy

Design or construction defects:
- Insufficient / inadequate reinforcement
- Insufficient / inadequate structural depth

Characteristics / Advantages	■ Non corrosive ■ Very high strength ■ Excellent durability ■ Lightweight ■ Unlimited lengths, no joints required ■ Low overall thickness, can be coated ■ Easy transportation (rolls) ■ Simple plate intersections or crossings ■ Very easy to install, especially overhead ■ Outstanding fatigue resistance ■ Minimal preparation of plate, applicable in several layers ■ Combinations of high strength and modulus of elasticity available ■ Clean edges without exposed fibers thanks to the pultrusion process ■ Approvals from many countries worldwide

Tests

Approval / Standards	Germany: Deutsches Institut für Bautechnik Z-36.12-80, 2010: General Construction Authorisation for Sika CarboDur®. France: CSTB - Avis Technique 3/07-502, SIKA CARBODUR SIKA WRAP Norway: NBI Teknisk Godkjenning, NBI Technical Approval, No. 2178, 2001, (Norwegian). Slovenia: ZAG, Technical Approval No. S418/99-620-2, za uporabo nacina ojacitev armirano betonskih in prednapetih elementov konstrukcij z dolepljenjem lamel iz karbonskih vlaken “Sika CarboDur®” v Republiki Sloneniji (Slovenian). Slovakia: TSUS, Building Testing and research institutes, Technical approval No. 5502A/02/0633/0/004, 2003: Systém dodatocného zosilnovania zelezobetonovych a drevenych konstrukcil Sika CarboDur® (Slovak). Poland: Instytut badawczy drog i mostow, technical approval No. AT/2003-04-0336, System materialow Sika CarboDur® do wzmacniania konstrukcji obiektow mostowych (Polish). Fib, Technical Report, bulletin 14: Externally bonded FRP reinforcement for RC structures, July 2001 (International). USA: ACI 440.2R-08, Guide for the Design and construction of Externally Bonded FRP Systems for strengthening concrete structures, July 2008, (USA). UK: Concrete Society Technical Report No. 55, Design guidance for strengthening concrete structures using fiber composite material, 2000 (UK). Switzerland: SIA 166, Klebebewehrungen, 2003 /2004 (CH). Italy: CNR-DT 200/2004 - Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Existing Structures

Product Data — Sika CarboDur® CFRP plates

Form

Appearance / Colour

Carbon fiber reinforced polymer with an epoxy matrix, black.

Packaging

Cut to size according parts list in nonreturnable cardboard packaging.
Supplied in rolls of 100 / 250 m in nonreturnable cardboard boxes.

Types

Sika CarboDur® S — Tensile E-Modulus 165'000 N/mm²

Type	Width	Thickness	Cross sectional area
Sika CarboDur® S1.525	15 mm	2.5 mm	37.5 mm²
Sika CarboDur® S212	20 mm	1.2 mm	24 mm²
Sika CarboDur® S214	20 mm	1.4 mm	28 mm²
Sika CarboDur® S2.025	20 mm	2.5 mm	50 mm²
Sika CarboDur® S512	50 mm	1.2 mm	60 mm²
Sika CarboDur® S514	50 mm	1.4 mm	70 mm²
Sika CarboDur® S612	60 mm	1.2 mm	72 mm²
Sika CarboDur® S613	60 mm	1.3 mm	78 mm²
Sika CarboDur® S614	60 mm	1.4 mm	84 mm²
Sika CarboDur® S812	80 mm	1.2 mm	96 mm²
Sika CarboDur® S814	80 mm	1.4 mm	112 mm²
Sika CarboDur® S912	90 mm	1.2 mm	108 mm²
Sika CarboDur® S914	90 mm	1.4 mm	126 mm²
Sika CarboDur® S1012	100 mm	1.2 mm	120 mm²
Sika CarboDur® S1014	100 mm	1.4 mm	140 mm²
Sika CarboDur® S1212	120 mm	1.2 mm	144 mm²
Sika CarboDur® S1213	120 mm	1.3 mm	156 mm²
Sika CarboDur® S1214	120 mm	1.4 mm	168 mm²
Sika CarboDur® S1512	150 mm	1.2 mm	180 mm²

Sika CarboDur® M (steel equivalent) — Tensile E-Modulus 210'000 N/mm²

Type	Width	Thickness	Cross sectional area
Sika CarboDur® M514	50 mm	1.4 mm	70 mm²
Sika CarboDur® M614	60 mm	1.4 mm	84 mm²
Sika CarboDur® M914	90 mm	1.4 mm	126 mm²
Sika CarboDur® M1014	100 mm	1.4 mm	140 mm²
Sika CarboDur® M1214	120 mm	1.4 mm	168 mm²
Sika CarboDur® M1514	150 mm	1.4 mm	210 mm²

Sika CarboDur® H — Tensile E-Modulus 300'000 N/mm²

Type	Width	Thickness	Cross sectional area
Sika CarboDur® H514	50 mm	1.4 mm	70 mm²

Storage

Storage Conditions / Shelf Life	Unlimited provided if there is no exposure to direct sunlight, dry conditions at temperatures of max. 50°C Transportation: only in original packaging or protected against any mechanical damaging

Technical Data

Density	1.60 g/cm^3
Temperature Resistance	> 150°C
Fiber Volume Content	> 68% (type S)

Mechanical / Physical Properties

Plate Properties

		Sika CarboDur®		
(numbers in N/mm^2 or MPa)		S	M	H
E-Modulus*	Mean Value	165'000	210'000	300'000
	Min. Value	> 160'000	> 200'000	> 290'000
	5% Fractile-Value	162'000	210'000	-
	95% Fractile-Value	180'000	230'000	-
Tensile Strength*	Mean Value	3'100	3'200	1'500
	Min. Value	> 2'800	> 2'900	> 1'350
	5% Fractile-Value	3'000	3'000	-
	95% Fractile-Value	3'600	3'900	-
Strain at break* (min. value)		> 1.70%	> 1.35%	> 0.45%

* Mechanical values obtained from longitudinal direction of fibers.

System Information

Sika CarboDur® + Sikadur®-30 or Sikadur®-30 LP

Application Details

Consumption

Width of plate	Sikadur®-30
50 mm	0.25 - 0.35 kg/m'
60 mm	0.30 - 0.40 kg/m'
80 mm	0.40 - 0.55 kg/m'
90 mm	0.50 - 0.70 kg/m'
100 mm	0.55 - 0.80 kg/m'
120 mm	0.65 - 1.00 kg/m'
150 mm	0.85 - 1.25 kg/m'

Dependent on the surface plane, profile and roughness of the substrate as well as any plate crossings and loss or wastage, the actual consumption of adhesive may be higher.

Substrate Quality

Evenness / plane or level: (according to FIB14)
The surface to be strengthened must be levelled, with variations and formwork marks not greater than 0.5 mm. Plane and level of the substrate to be checked with a metal batten. Tolerance for 2 m length max. 10 mm and for 0.3 m length 4 mm. These tolerances shall be adapted to local guidelines.

Substrate strength (concrete, masonry, natural stone) must be verified in all cases: Mean adhesive tensile strength of the prepared concrete substrate shall be 2.0 N/mm^2, min. 1.5 N/mm^2. If these values can not be reached, then see the SikaWrap® Fabric Product Data Sheets for alternative Sika® solutions.

Concrete must be older than 28 days (dependent on environment and strengths).

Substrate Preparation

Concrete and masonry:
Substrates must be sound, dry, clean and free from laitance, ice, standing water, grease, oils, old surface treatments or coatings and any loosely adhering particles.

Concrete must be cleaned and prepared to achieve a laitance and contaminant free, open textured surface.

Repairs and levelling: If carbonised or weak concrete cover has to be removed or levelling of uneven surfaces is needed, the following systems may be applied:

(Details on application and limitation see the relevant Product Data Sheets)

- Protection of corroded rebars: SikaTop® Armatec® 110 EpoCem®
- Structural repair materials: Sikadur®-41 epoxy repair mortar, Sikadur®-30 adhesive or cementitious Sika® MonoTop®-412 (horizontal, vertical, overhead) or Sika® MonoTop®-438 (horizontal, top-side) range.

Timber surfaces:
Must be prepared by planing, grinding or sanding. Dust must be removed by vacuum.

Steel surfaces:
Must be prepared by blastcleaning to Sa 2.5 free from grease, oil, rust and any other contaminants which could reduce or prevent adhesion.
Use the correct primer (see table).

Be careful to avoid water condensation on the surfaces (dew point conditions). Priming can be done with Icosit-277 or with Sikagard®-63 N as temporary corrosion protection; or Icosit-EG1 as permanent corrosion protection.

	+10°C	+20°C	+30°C
1) Maximum waiting time between - Blastcleaning of steel and - Primer / or Sikadur®-30 (application without priming possible, if no corrosion protection is needed)	48 hours	48 hours	48 hours
2) Minimum waiting time between - Primer and - Sikadur®-30 application (**without** additional preparation of the Primer)	48 hours	24 hours	12 hours
3) Maximum waiting time between - Primer and - Sikadur®-30 application (**without** additional preparation of the Primer)	7 days	3 days	36 hours
4) Waiting time between - Primer and - Sikadur®-30 application (**with** additional preparation of the Primer)*	> 7 days	> 3 days	> 36 hours

*If additional preparation of the primer is necessary (4), it shall be done at earliest the day before application. After preparation of the Primer, the surface has to be cleaned / vacuumed free from dust.

Plate preparation:
Prior to the application of Sikadur®-30, solvent wipe the bonding surface with Sika® Colma Cleaner to remove contaminants. Wait until the surface is dry before applying the adhesive (> 10 minutes).

Application Conditions / Limitations

Substrate Temperature	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.
Ambient Temperature	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.
Substrate Moisture Content	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.
Dew Point	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.

Application Instructions

Mixing	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.
Mixing Time	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.
Application Method / Tools	See the Method Statement of Sika CarboDur®.
Cleaning of Tools	Clean all tools and application equipment with Sika® Colma Cleaner immediately after use. Cured material can only be removed mechanically.
Potlife	See the Product Data Sheets of Sikadur®-30 and Sikadur®-30 LP.
Notes on Application / Limitations	A suitably qualified Engineer must be responsible for the design of the strengthening works. **This application is structural and great care must be taken in selecting suitably experienced and trained specialist labour.** Only apply plates within the open time of Sikadur®-30. Site quality control shall be supported / monitored by an independent testing authority. Care must be taken when cutting plates. Use suitable protective clothing, gloves, eye protection and respirator. The Sika CarboDur® system must be protected from permanent exposure to direct sunlight, to water and/or moisture and from direct contact to wet concrete. Coating: The exposed plate-surface can be painted with a coating material such as Sikagard®-550 W Elastic or Sikagard®-ElastoColor W for UV and water and/or moisture protection. Maximum permissible service temperature is approx. +50°C. Note: When using the Sika® CarboHeater together with Sikadur®-30 LP this can be increased to max. +80°C (see the Sika® CarboHeater Product Data Sheet). The instructions in the Technical Data Sheet must be followed when applying Sikadur®-30 adhesive. Note: Detailed advice on the above must always be obtained from Sika® Services AG.
Fire Protection	If required Sika CarboDur® plates may be protected with fire resistant material.

Construction

Value Base

All technical data stated in this Product Data Sheet are based on laboratory tests. Actual measured data may vary due to circumstances beyond our control.

Health and Safety Information

For information and advice on the safe handling, storage and disposal of chemical products, users shall refer to the most recent Material Safety Data Sheet containing physical, ecological, toxicological and other safety-related data.

Legal Notes

The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions in accordance with Sika's recommendations. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The user of the product must test the product's suitability for the intended application and purpose. Sika reserves the right to change the properties of its products. The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users must always refer to the most recent issue of the local Product Data Sheet for the product concerned, copies of which will be supplied on request.

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Construction

Sika MonoTop® R

Polymer modified cementitious hand placed / wet spray repair mortar

Product Description

Sika MonoTop® R is a one part, thixotropic, polymer modified, cementitious mortar containing silica fume.

Sika MonoTop® R cures to produce a high strength mortar with enhanced polymeric properties.

Sika MonoTop® R exhibits high bond strength, greatly reduced water and carbon dioxide permeability and improved resistance to oils and chemicals.

Uses

- Fast repairs to horizontal or vertical concrete or mortar surfaces above and below ground level
- Filling/repair mortar for voids, honeycombed areas, etc.
- Repair of spalled concrete caused by reinforcement corrosion
- Spray applied repairs
- Repairs with improved resistance to oils, sewage, chemicals, etc.

Characteristics / Advantages

- Fast and easy to apply in layers up to 20 mm thick
- 1-part system requiring only addition of clean water
- Compatible with the thermal expansion properties of concrete
- Chloride free
- Non-corrosive to reinforcing steel
- Non-toxic, suitable for potable water
- Contains fibres to prevent micro cracking
- Non-shrink
- Excellent freeze / thaw resistance
- Good resistance to water immersion

Product Data

Form

Appearance / Colour	Concrete grey powder
Packaging	25 kg bags

Storage

Storage Conditions / Shelf Life	6 months from the date of production if stored properly in original, unopened and undamaged sealed packaging in dry conditions. Keep away from direct sunlight.

Technical Data

Density	Freshly mixed mortar ~ 2.0 kg/ltr	
Layer Thickness	20 mm max. (vertical application) / 3 mm min.	
Water Absorption	< 3% (at 30 mm)	(BS 1881: Part 122)

Mechanical / Physical Properties

Compressive Strength	■ 1 day ■ 28 days	> 15.0 N/mm^2 (+25°C) > 50.0 N/mm^2 (+25°C)
Bond Strength on Concrete	> 1.5 N/mm^2 (with bonding bridge)	
Modulus of Elasticity	< 20,000 N/mm^2	

System Information

System Structure

Sika MonoTop® System comprises:

- Sika MonoTop®-610 MY bonding bridge and reinforcement protection
- Sika MonoTop®-615 SD or Sika MonoTop® R hand and wet spray applied repair mortar
- Sika MonoTop®-620 MY pore sealer / fairing coat

Application Details

Consumption

- ~ 71 bags per m^3
- 1 bag yields ~ 14 litres of mortar

Substrate Quality

Concrete

All concrete and mortar substrates must be structurally sound, laitance free, clean and free from dirt, oil, grease or other surface contaminants. All loose or friable particles must be removed.

Steel reinforcements

Steel reinforcement surfaces must be clean from rust, oil, grease or any other loosely adhering particles to provide a rust free surface.

Substrate Preparation / Priming

Concrete

For large concrete areas, grit or grit-water blasting, scarifying or scabbling is recommended. For small areas and “spot” repairs, needle gunning or scabbling is effective.

The prepared substrate should be thoroughly soaked with clean water until uniformly saturated but with no standing surface water. This condition is referred to as saturated surface dry (SSD) and care should be taken to remove any cement slurry or dust produced during surface preparation. The use of a “fan” shaped water jet is ideal.

Steel reinforcement

Surfaces should be prepared using approved abrasive blast cleaning techniques e.g. wire-brushed or water / grit blasted and primed with 2 coats of Sika MonoTop®-610 MY (refer to Sika MonoTop®-610 MY data sheet).

Application Conditions / Limitations

Application Temperature	+6°C min. / +40°C max.

Application Instructions

Mixing Ratio	*Hand application* Approximately 3.4 – 3.5 litres of clean water per 25 kg bag as per required consistency. *Wet spray application* 3.4 – 4.5 litres of clean water per 25 kg bag.
Mixing	Sika MonoTop® R should be mechanically mixed in a clean drum using a drill and paddle. A normal concrete mixer is not suitable. Pour the mixing water into a clean drum. While stirring slowly, add Sika MonoTop® R to the water. Mix for a minimum 3 minutes to ensure that the components are thoroughly blended and at a maximum speed of 500 rpm to minimise air entrainment. Mix only what you require taking into consideration the pot life of the material.
Application Method / Tools	*Hand application* Work "wet on wet" the mixed mortar well into the substrate, using a placing rather than a rendering technique to fill all pores and voids. Compact well. Force material against the edge of the repair, working towards the centre. For repairs in excess of 20 mm deep, apply in layers and form keys for the subsequent layers. If previous layers are over 48 hours old, needle gun the surface and dampen before applying the next layer. Steel trowel the final coat if required. The Sika MonoTop® R and surrounding areas can be further treated with SikaTop® Seal-107 or Sika MonoTop®-620 MY to provide a water and carbonation resistant finish. *Sprayed application* The repair mortar shall be placed onto the pre-wetted substrate between the minimum and maximum layer thicknesses without the formation of voids and loose rebound material. Where layers are to be built up to prevent sagging or slumping, each layer should be allowed to stiffen before applying subsequent layers "wet on wet". When layers cannot be applied "wet on wet", or if more than 24 hours between layers apply, apply a bonding primer of Sika® MonoTop-610 MY or SikaTop® Armatec-110 EpoCem® and apply repair mortar "wet on wet". Finishing for both hand and spray applications should be done to the required surface texture as soon as the mortar has started to stiffen.
Cleaning of Tools	Clean all tools and application equipment with water immediately after use. Hardened and/or cured material can only be mechanically removed.
Pot Life	~ 20 minutes (+30°C)
Notes on Application / Limitations	Repairs with Sika® MonoTop® System cannot bridge live cracks or moving joints, etc. Repairs in excess of 20 mm must be layered. Sika MonoTop® mortars that are wetted during the initial cure period may produce a white "bloom" on the surface which does not affect the long term properties of the mortar.

Curing Details

Applied Product Ready for Use	To achieve the full potential of any cement based products, curing is essential. This can be carried out with the application of a curing compound such as Antisol® E or with other curing practices such as covering with polythene sheets or damp hessian for 3 days.

Construction

Value Base

All technical data stated in this Product Data Sheet are based on laboratory tests. Actual measured data may vary due to circumstances beyond our control.

Health and Safety Information

For information and advice on the safe handling, storage and disposal of chemical products, users shall refer to the most recent Material Safety Data Sheet (available upon request) containing physical, ecological, toxicological and other safety-related data.

Legal Note

The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions in accordance with Sika's recommendations. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The user of the product must test the product's suitability for the intended application and purpose. Sika reserves the right to change the properties of its products. The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users must always refer to the most recent issue of the local Product Data Sheet for the product concerned, copies of which will be supplied on request.

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Construction

Sika® Unitherm® 38091 exterior

Solvent based fire protection coating for steel, exterior use

Product Description	Sika Unitherm 38091 exterior is a solvent based thin film fire protection coating system which has to be used for structural steelwork which is subject to weathering, high humidity, maritime environment etc. (exterior condition). Sika Unitherm 38091 exterior can also be used for interior steel constructions. Sika Unitherm 38091 exterior is forming a heat insulating layer under the influence of fire and improves the fire resistance of steel parts like columns, girders and framework.
Application areas:	For exterior use on structural steel members like columns, girders and framework with a highly effective protection to delay the steel from reaching critical temperatures. Note: With critical situation i.e. frequent formation of condensation and/or heating up of surfaces above 45°C, possible special measures should be taken.
Characteristics / Advantages:	■ Applicable on steel constructions exposed to weathering ■ Preserves the appearance of a steel construction ■ Applicable to filigree steel structures and complex steel building elements ■ Does not increase static load ■ Simple application ■ Individual coloration possible with corresponding topcoat, various colour shades in RAL, others available

Test

Approval / Standards	Conforms to the requirements of GB14907-2002

Product Data

Colour shades:	White
Packaging:	25.0 kg containers, net weight
Shelf-Life:	18 months from production in cool and dry storage conditions, original unopened containers, in dry conditions at temperatures between +5°C and +30°C. Protect from frost.

Systems

Coating systems	<u>Steel:</u>	
	Primer	Sika Permacor 1705
	Intumescent coating	Sika Unitherm 38091 exterior
	Topcoat	Sika Unitherm Top S
	<u>Galvanised steel:</u>	
	Interface	Sika Permacor 2706/EG
	Intumescent coating	Sika Unitherm 38091 exterior
	Topcoat	Sika Unitherm Top S

Surface pre-treatment:	Steel: Blast cleaning to Sa 2 $^{1}/_{2}$ according to EN ISO 12944, Part 4. Galvanised steel: Free from dirt, oil, grease and corrosion products. Existent anticorrosive primer/coatings: A compatibility test with the fire protection system is recommended. For testing and surface pre-treatment please see special technical information sheet "Primers and surface testing for Sika Unitherm steel fire protection systems". Any damage (impact, corrosion, etc.) should be repaired prior the coating.

Technical Data

Mass Density	Resin liquid: ~ 1.28 kg/l
Solid Content	~ 70% (by weight)
Flash Point	+26°C
Consumption:	Example: 550 microns dry - 750 to 800 microns wet - 1000 g/m^2 - 0.780 l/m^2 Fire rate Sika Unitherm 38091 interior depends on national standard. See corresponding separate consumption table/diagram. Note: Ratio dry film thickness - wet film thickness varies depending on application method.

Application instructions

Preparation of coating material:	Stir thoroughly with slowly turning mechanical stirrer, free of lumps.
Application conditions:	Object temperature not below + 5°C, to max. + 50°C Relative humidity max. 80% Application temperature shall be at least ≥ 3 K above dew point. In case relative humidity exceeds 80% special measures must be taken to prevent the condensation forming while application. During application and drying of total Sika Unitherm coating system including Sika Unitherm Top S topcoat as well as transportation special protection measures must be taken against weathering.
Application methods:	Airless spraying: - material shall be applied undiluted - Airless spray equipment with transmission ≥ 45: 1, flow rate 4 - 5 l/min. - filters should be removed - hose diameter not below 3/8 " - recommended nozzle size 0.46 - 0.66 mm or 0.019 - 0.027 " - Solvent resistant hoses must be used! Brushing/rolling: - More than one coat may be necessary to give equivalent dry film thickness of a single spray applied coat. Note: The Sika Unitherm basecoat shall be applied in several coats up to the final dry film thickness required. Wet film thickness max. 400 µm for 1st application coat on primer. Wet film thickness approx. 500 µm for each subsequent application coat is recommended.
Drying:	Approx. 24 hours for each fire protection coat for exterior use at + 20°C object temperature and 65% relative humidity. Lower temperatures, higher relative humidity and different fire protection coating thicknesses may extend drying time. Sika Unitherm 38091 exterior requires a minimum of 48 hours drying prior to application of topcoat Sika Unitherm Top S. Through-drying of Sika Unitherm 38091 exterior can be checked by "fingernail-test".
Topcoat:	Topcoat Sika Unitherm Top S produced in RAL colour shades or on request for other colour shades. For exterior use: 2 x 150 g/ m^2, 2 x 120 ml/m^2 is necessary for structural steelwork exposed to weathering (see separate technical data sheet for topcoat).
Clean Tools	Use Sika Thinner C cleans the tools and equipments after application.

Construction

Waiting Time / Overcoating

Before applying Sika® Unitherm®-38091 exterior - on Sika Permacor®-1705 or Sika Permacor®-2706 EG - allow:

Substrate temperature	Minimum	Maximum
+10°C	24 hours	10 days
+20°C	16 hours	7 days
+30°C	16 hours	5 days

Before applying Sika® Unitherm®-38091 exterior - on Sika® Unitherm®-38091 exterior - allow:

Substrate temperature	Minimum	Maximum
+10°C	48 hours	-
+20°C	24 hours	-
+30°C	24 hours	-

Before applying Sika® Unitherm® Top S- on Sika® Unitherm®-38091 exterior - allow:

Substrate temperature	Minimum	Maximum
+10°C	72 hours	-
+20°C	48 hours	-
+30°C	48 hours	-

Times are approximate and will be affected by changing ambient conditions particularly temperature and relative humidity.

Important notice

Health and Safety Information

Please observe safety instructions on container labels and local regulations. Dangerous Goods regulations have to be followed.

During application in closed rooms, pits and shafts etc., sufficient ventilation must be provided. Keep away open light, including welding.

In poorly lit rooms only electric safety lamps are permitted. The installed ventilation equipment must be spark-proof.

In a liquid or not fully cured state, the thinner and the products contaminate water and should not be allowed to enter drains or be spilled onto open ground. All spillages and liquid waste must be removed according to local Health and Safety regulations.

Further details are contained in our instructions “Health protection and the prevention of accidents“.

Value Base

All technical data stated in this Product Data Sheet are based on laboratory tests. Actual measured data may vary due to circumstances beyond our control.

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Construction

Sikadur®-30

Adhesive for bonding reinforcement

Product Description

Sikadur®-30 is a thixotropic, structural two part adhesive, based on a combination of epoxy resins and special filler, designed for use at normal temperatures between +8°C and +35°C.

Uses

Adhesive for bonding structural reinforcement, particularly in structural strengthening works. Including:

- Sika CarboDur® Plates to concrete, brickwork and timber (for details see the Sika CarboDur® Product Data Sheet, the "Method Statement for Sika CarboDur® Externally Bonded Reinforcement" Ref: 850 41 05 and the "Method Statement for Sika CarboDur® Near Surface Mounted Reinforcement" Ref: 850 41 07).
- Steel plates to concrete (for details see the relevant Sika Technical information).

Characteristics / Advantages

Sikadur®-30 has the following advantages:

- Easy to mix and apply.
- No primer needed.
- High creep resistance under permanent load.
- Very good adhesion to concrete, masonry, stonework, steel, cast iron, aluminium, timber and Sika CarboDur® Plates.
- Hardening is not affected by high humidity.
- High strength adhesive.
- Thixotropic: non-sag in vertical and overhead applications.
- Hardens without shrinkage.
- Different coloured components (for mixing control).
- High initial and ultimate mechanical resistance.
- High abrasion and shock resistance.
- Impermeable to liquids and water vapour.

Tests

Approval / Standards

IBMB, TU Braunschweig, test report No. 1871/0054, 1994: Approval for Sikadur®-30 Epoxy adhesive.

IBMB, TU Braunschweig, test report No. 1734/6434, 1995: Testing for Sikadur®-41 Epoxy mortar in combination with Sikadur®-30 Epoxy adhesive for bonding of steel plates.

Testing according to EN 1504-4

Product Data

Form

Colours

Part A:	white
Part B:	black
Parts A+B mixed:	light grey

Packaging

6 kg (A+B): pre-batched unit, pallets of 480 kg (80 x 6 kg).

Not pre-dosed industrial packaging (pallets at 14 pails):
Part A: 30 kg pails
Part B: 10 kg pails

Storage

Storage Conditions / Shelf-Life

24 months from date of production if stored properly in original unopened, sealed and undamaged packaging in dry conditions at temperatures between +5°C and +30°C. Protect from direct sunlight.

Technical Data

Chemical Base

Epoxy resin.

Density

1.65 kg/l ± 0.1 kg/l (parts A+B mixed) (at +23°C)

Sag Flow

(According to FIP (Fédération Internationale de la Précontrainte))

On vertical surfaces it is non-sag up to 3-5 mm thickness at +35°C.

Squeezability

(According to FIP (Fédération Internationale de la Précontrainte))

4'000 mm^2 at +15°C at 15 kg

Layer Thickness

30 mm max.

When using multiple units, one after the other. Do not mix the following unit until the previous one has been used in order to avoid a reduction in handling time.

Change of Volume

Shrinkage:
0.04% (According to FIP (Fédération Internationale de la Précontrainte))

Thermal Expansion Coefficient

Coefficient W:
2.5 x 10^{-5} per °C (temp. range -20°C to +40°C)

Thermal Stability

Glass transition temperature:

(According to FIP (Fédération Internationale de la Précontrainte))

Curing time	Curing Temperature	TG
7 days	+45°C	+62°C

Heat deflection temperature: (According to ASTM-D 648)

Curing time	Curing Temperature	HDT
3 hours	+80°C	+53°C
6 hours	+60°C	+53°C
7 days	+35°C	+53°C
7 days	+10°C	+36°C

Service Temperature

-40°C to +45°C (when cured at > +23°C)

Mechanical / Physical Properties

Compressive Strength

(According to EN 196)

	Curing temperature	
Curing time	+10°C	+35°C
12 hours	-	80 - 90 N/mm^2
1 day	50 - 60 N/mm^2	85 - 95 N/mm^2
3 days	65 - 75 N/mm^2	85 - 95 N/mm^2
7 days	70 - 80 N/mm^2	85 - 95 N/mm^2

Shear Strength Concrete failure (~ 15 N/mm^2) (According to FIP 5.15)

Curing time	Curing temperature +15°C	Curing temperature +35°C
1 day	3 - 5 N/mm^2	15 - 18 N/mm^2
3 days	13 - 16 N/mm^2	16 - 19 N/mm^2
7 days	14 - 17 N/mm^2	16 - 19 N/mm^2

18 N/mm^2 (7 days at +23°C) (According to DIN 53283)

Tensile Strength (According to DIN 53455)

Curing time	Curing temperature +15°C	Curing temperature +35°C
1 day	18 - 21 N/mm^2	23 - 28 N/mm^2
3 days	21 - 24 N/mm^2	25 - 30 N/mm^2
7 days	24 - 27 N/mm^2	26 - 31 N/mm^2

Bond Strength On steel > 21 N/mm^2 (mean values > 30 N/mm^2) (According to DIN EN 24624) on correctly prepared substrate, ie. blastcleaned to Sa. 2.5

On concrete: (According to FIP (Fédération Internationale de la Précontrainte)) concrete failure (> 4 N/mm^2)

E-Modulus Compressive: 9'600 N/mm^2 (at +23°C) (According to ASTM D695)
Tensile: 11'200 N/mm^2 (at +23°C) (initial, According to ISO 527)

System Information

System Structure Sika CarboDur® System: For Application Details of Sika CarboDur® Plates with Sikadur®-30, see the "Method Statement for Sika CarboDur® Externally Bonded Reinforcement" Ref: 850 41 05 and the "Method Statement for Sika CarboDur® Near Surface Mounted Reinforcement" Ref: 850 41 07

Application Details

Substrate Quality See the Product Data Sheet of Sika CarboDur® Plates and Sika CarboDur® BC rods

Substrate Preparation See the "Method Statement for Sika CarboDur® Externally Bonded Reinforcement" Ref: 850 41 05 and the "Method Statement for Sika CarboDur® Near Surface Mounted Reinforcement" Ref: 850 41 07

Application Conditions / Limitations

Substrate Temperature +8°C min. / +35°C max.

Ambient Temperature +8°C min. / +35°C max.

Material Temperature Sikadur®-30 must be applied at temperatures between +8°C and +35°C.

Substrate Moisture Content Max. 4% pbw
When applied to mat damp concrete, brush the adhesive well into the substrate.

Dew Point Beware of condensation!
Substrate temperature during application must be at least 3°C above dew point.

Application Instructions

Mixing Part A : part B = 3 : 1 by weight or volume
When using bulk material the exact mixing ratio must be safeguarded by accurately weighing and dosing each component.

Construction

Mixing Time

Pre-batched units:
Mix parts A+B together for at least 3 minutes with a mixing spindle attached to a slow speed electric drill (max. 300 rpm) until the material becomes smooth in consistency and a uniform grey colour. Avoid aeration while mixing. Then, pour the whole mix into a clean container and stir again for approx. 1 more minute at low speed to keep air entrapment at a minimum. Mix only that quantity which can be used within its potlife.

Bulk packing, not pre-batched:
First, stir each part thoroughly. Add the parts in the correct proportions into a suitable mixing pail and stir correctly using an electric low speed mixer as above for pre-batched units.

Application Method / Tools

See the "Method Statement for Sika CarboDur® Externally Bonded Reinforcement" Ref: 850 41 05 and the "Method Statement for Sika CarboDur® Near Surface Mounted Reinforcement" Ref: 850 41 07

Cleaning of Tools

Clean all tools and application equipment with Sika® Colma Cleaner immediately after use. Hardened / cured material can only be mechanically removed.

Potlife

(According to FIP (Fédération Internationale de la Précontrainte))

Temperature	+8°C	+20°C	+35°C
Potlife	~ 120 minutes	~ 90 minutes	~ 20 minutes
Open time	~ 150 minutes	~ 110 minutes	~ 50 minutes

The potlife begins when the resin and hardener are mixed. It is shorter at high temperatures and longer at low temperatures. The greater the quantity mixed, the shorter the potlife. To obtain longer workability at high temperatures, the mixed adhesive may be divided into portions. Another method is to chill parts A+B before mixing them (not below +5°C).

Notes on Application / Limitations

Sikadur® resins are formulated to have low creep under permanent loading. However due to the creep behaviour of all polymer materials under load, the long term structural design load must account for creep. Generally the long term structural design load must be lower than 20-25% of the failure load. Please consult a structural engineer for load calculations for your specific application.

Value Base

All technical data stated in this Product Data Sheet are based on laboratory tests. Actual measured data may vary due to circumstances beyond our control.

Local Restrictions

Please note that as a result of specific local regulations the performance of this product may vary from country to country. Please consult the local Product Data Sheet for the exact description of the application fields.

Health and Safety Information

For information and advice on the safe handling, storage and disposal of chemical products, users shall refer to the most recent Material Safety Data Sheet containing physical, ecological, toxicological and other safety-related data.

Legal Notes

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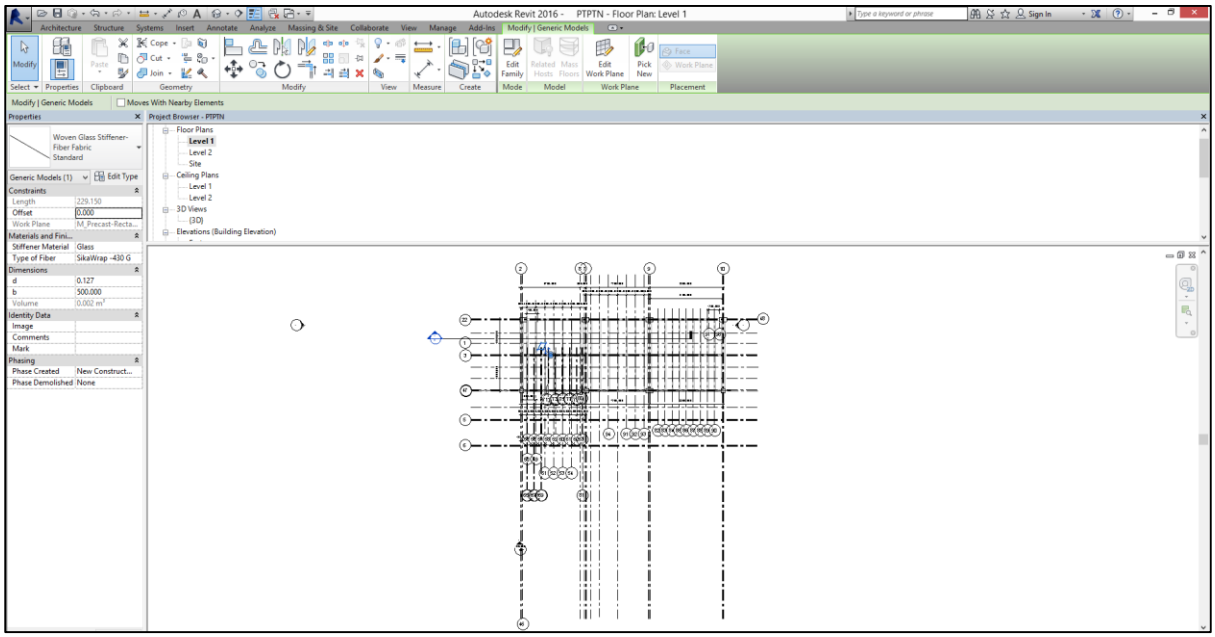
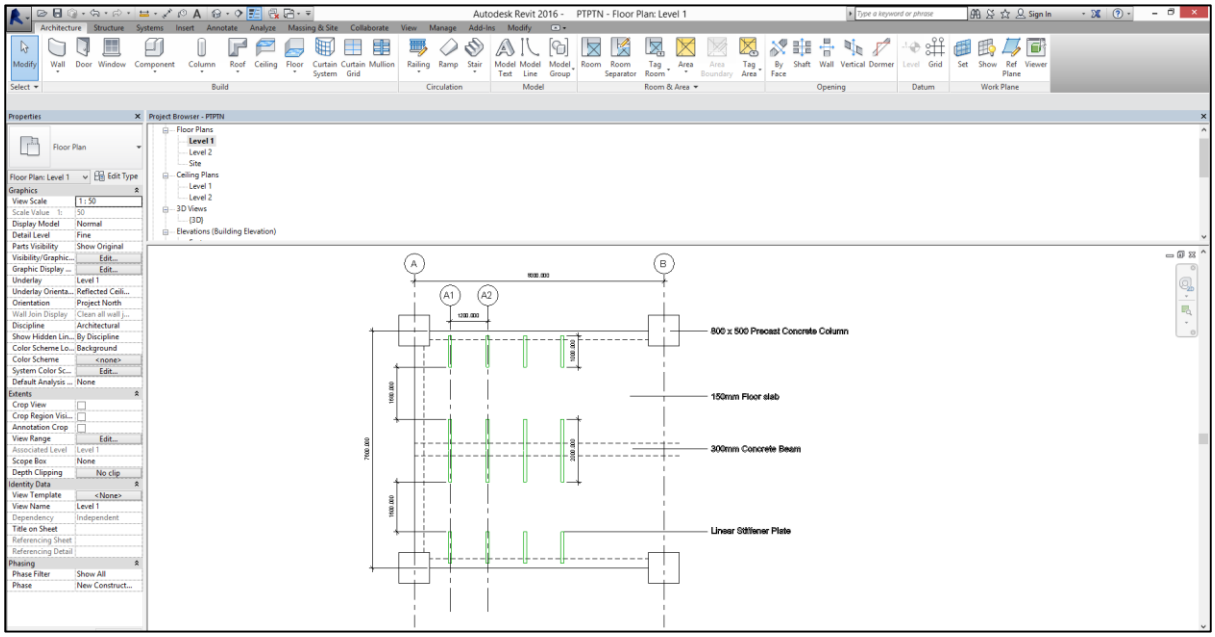
SEMAKAN LUKISAN SIAP BINA G2 PTPTN (DATA CENTRE)

PELAN LANTAI

1. GARIS RUJUKAN SETIAP ELEMEN TIDAK JELAS. GARIS RUJUKAN HENDAKLAH MERUJUK KEPADA KEDUDUKAN ELEMEN UTAMA SEPERTI ‘COLUMN’, ‘BEAM’, ‘LINEAR STIFFENER PLATE’, ‘WOVEN GLASS STIFFENER’ DLL BAGI MENUNJUKKAN KETEPATAN KEDUDUKAN DAN PEMASANGAN SETIAP ELEMEN.
2. UKURAN SETIAP ELEMEN TIDAK JELAS. UKURAN DAN JARAK SETIAP ELEMEN UTAMA PERLU DITUNJUKKAN SEBAGAI RUJUKAN.
3. SPESIFIKASI SETIAP ELEMEN PERLU DINYATAKAN SEBAGAI RUJUKAN.



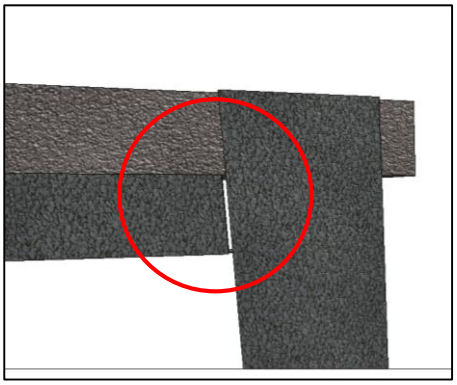
LUKISAN SEDIA ADA YANG DISEMAK

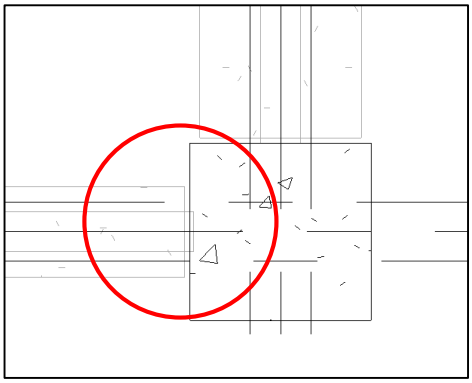


CONTOH FORMAT GARIS RUJUKAN, UKURAN DAN SPESIFIKASI

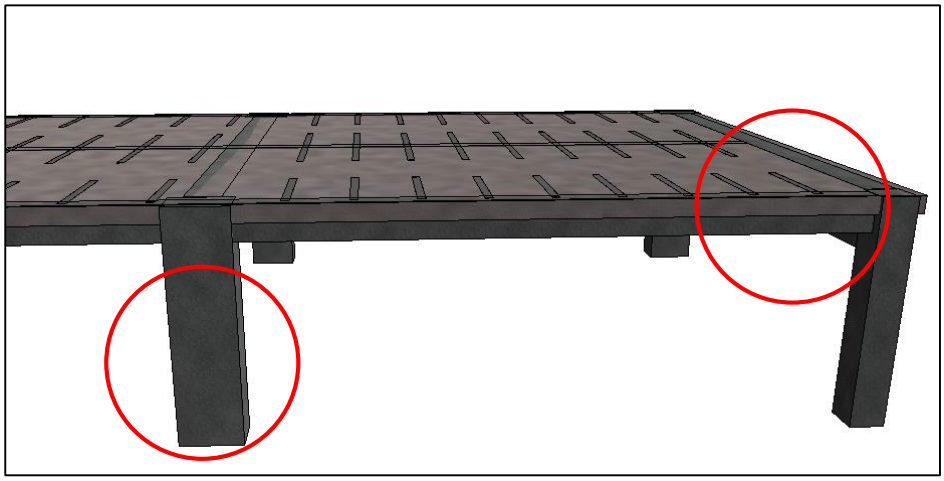
3D MODELLING

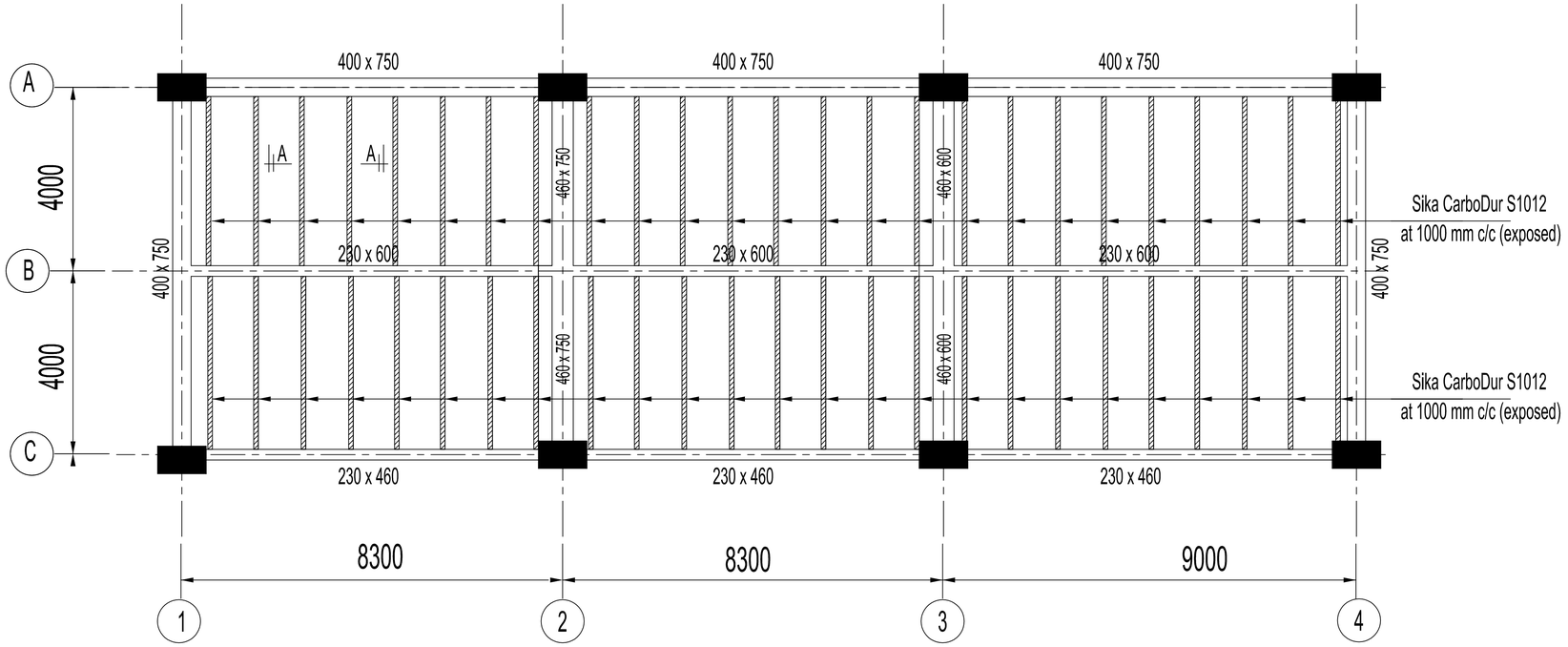
1. SEMAK KETEPATAN SETIAP SAMBUNGAN ELEMEN. TERDAPAT BEBERAPA SAMBUNGAN YANG TIDAK TEPAT.



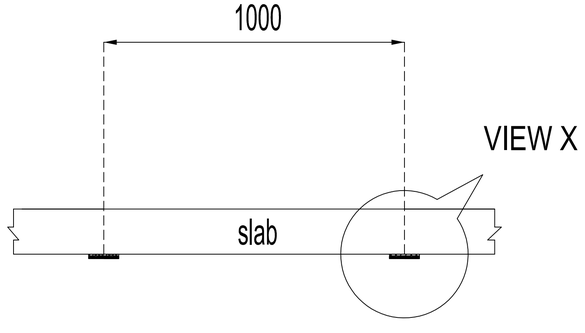


2. SEMAK KETEPATAN SAIZ, KEDUDUKAN DAN JARAK ANTARA ‘COLUMN’ DAN ‘BEAM’ MENGIKUT SPESIFIKASI SEDIA ADA DI TAPAK.

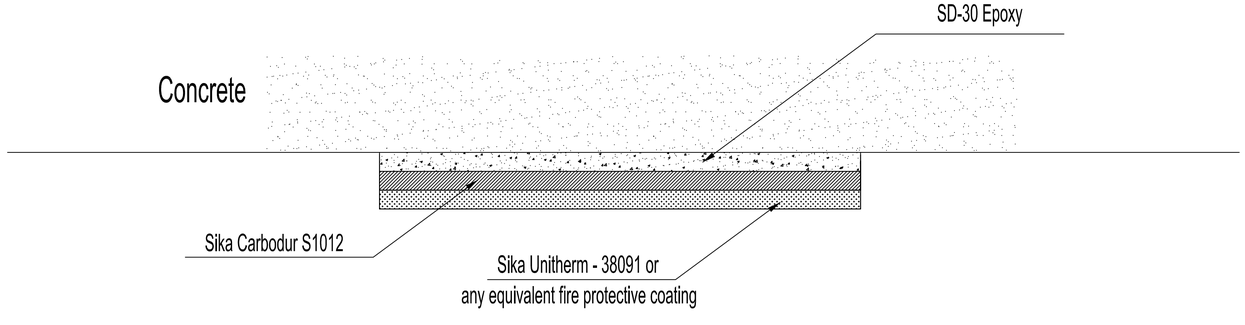




BOTTOM SLAB LAYOUT PLAN



SECTION A-A



VIEW X (Exposed)

PINDAAN	TARIKH	CATITAN

TAJUK LUKISAN :

CADANGAN KERJA-KERJA MENGUKUH STRUKTUR LANTAI PUSAT DATA, ARAS 9, KE ATAS 1 BLOK (BLOK D - MENARA PEJABAT) YANG SEDIA ADA DI ATAS LOT PT. 13 & 88, JALAN YAP KWAN SENG, SEKSYEN 44, WILAYAH PERSEKUTUAN KUALA LUMPUR.

UNTUK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN)

PEMILIK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN) LOT G-2 TINGKAT BAWAH WISMA CHASE PERDANA, OFF JALAN SEMANATAN, DAMANSARA HEIGHTS, 50490, KUALA LUMPUR

TANDATANGAN PEMILIK :

.....

TAJUK LUKISAN :

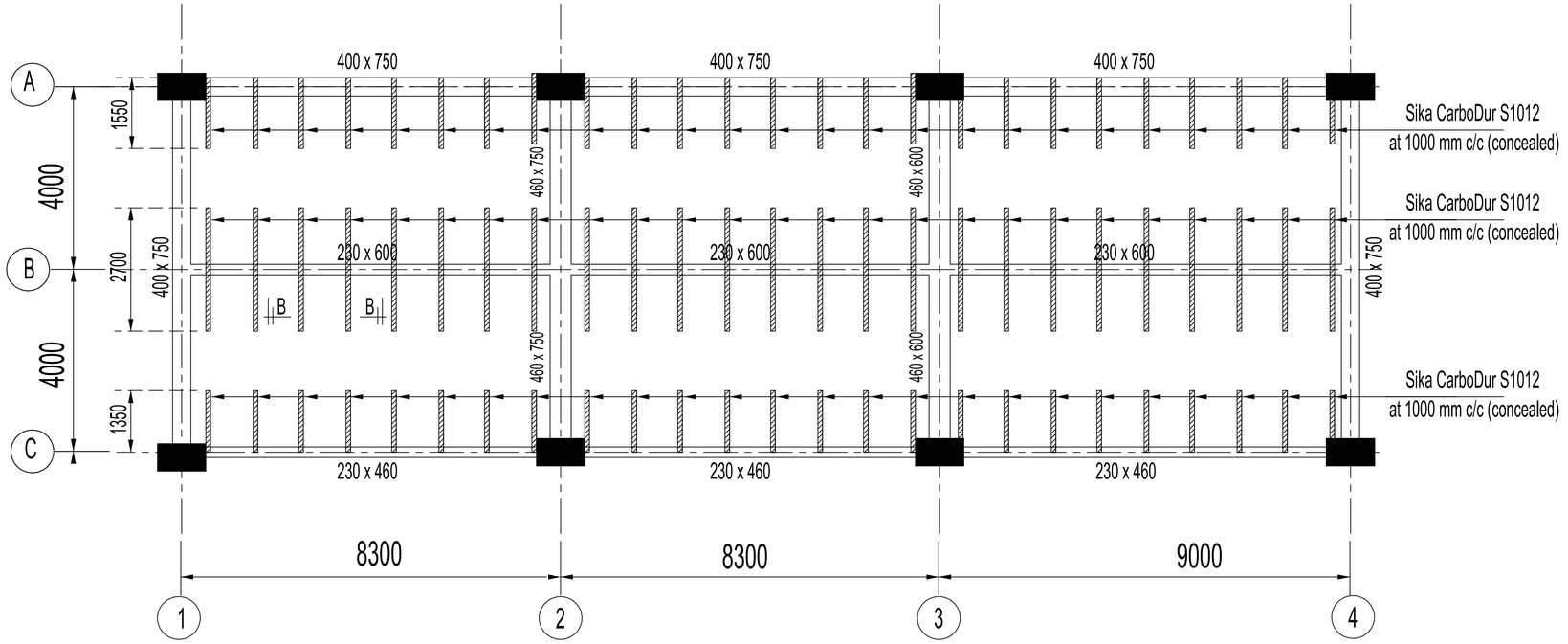
BOTTOM SLAB LAYOUT PLAN

- CFRP STRENGTHENING

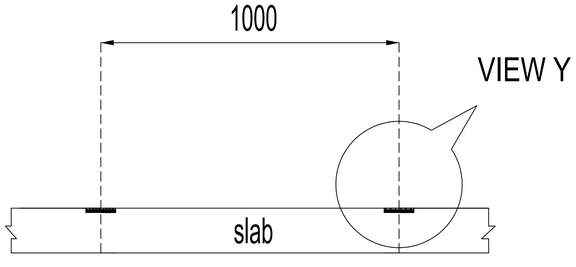
SKALA :	TARIKH : JANUARY 2015
DI R/BENTUK OLEH : AAM, SB & NH	DI SEMAK OLEH : IR .SALMIZI

NOMBOR LUKISAN :

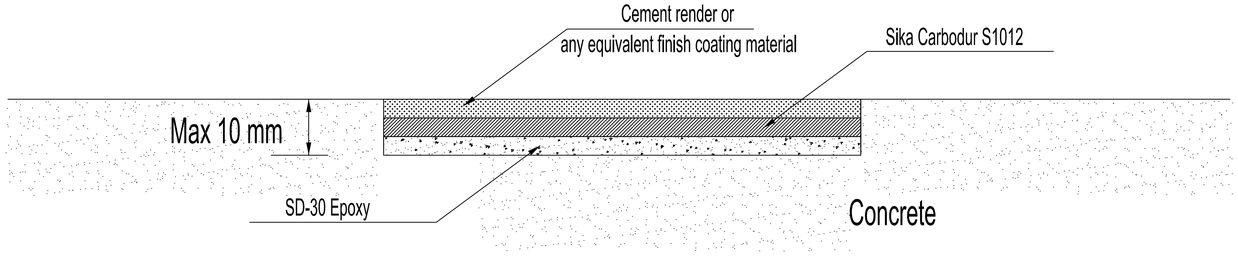
PTPTN/01/CFRP



TOP SLAB LAYOUT PLAN



SECTION B-B



VIEW Y (Concealed)

KONTRAKTOR HENDAKLAH MEMERIKSA SEMUA DIMENSI. HANYA DIMENSI YANG BERTULIS BOLEH DIGUNAKAN. SEBARANG KEMUSYKILAN HENDAKLAH DILAPORKAN KEPADA JURUTERA DENGAN SEGERA SEBELUM MEMULAKAN KERJA.

PINDAAN	TARIKH	CATITAN

TAJUK LUKISAN :

CADANGAN KERJA-KERJA MENGUKUH STRUKTUR LANTAI PUSAT DATA, ARAS 9, KE ATAS 1 BLOK (BLOK D - MENARA PEJABAT) YANG SEDIA ADA DI ATAS LOT PT. 13 & 88, JALAN YAP KWAN SENG, SEKSYEN 44, WILAYAH PERSEKUTUAN KUALA LUMPUR.

UNTUK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN)

PEMILIK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN) LOT G-2 TINGKAT BAWAH WISMA CHASE PERDANA, OFF JALAN SEMANATAN, DAMANSARA HEIGHTS, 50490, KUALA LUMPUR

TANDATANGAN PEMILIK :

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TAJUK LUKISAN :

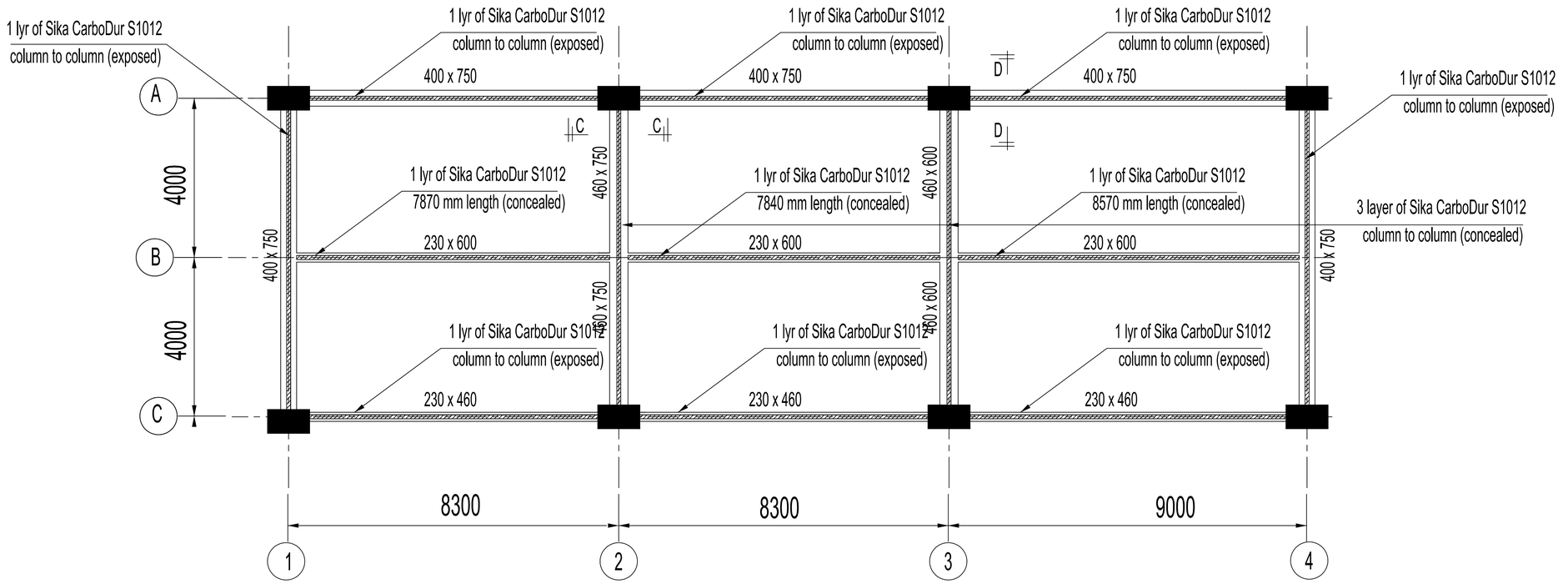
TOP SLAB LAYOUT PLAN

- CFRP STRENGTHENING

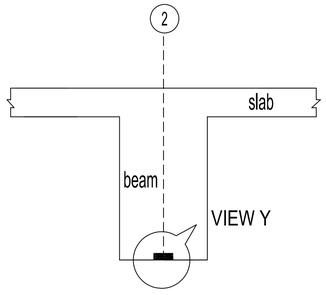
SKALA :	TARIKH : JANUARY 2015
DI R/BENTUK OLEH : AAM, SB & NH	DI SEMAK OLEH : IR .SALMIZI

NOMBOR LUKISAN :

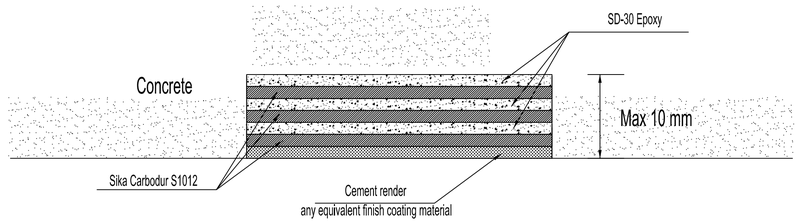
PTPTN/02/CFRP



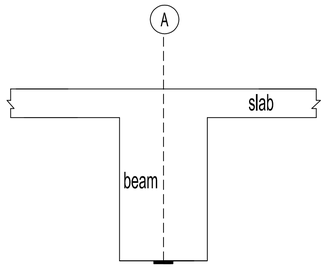
BOTTOM BEAM LAYOUT PLAN



SECTION C-C



VIEW Y (Concealed)



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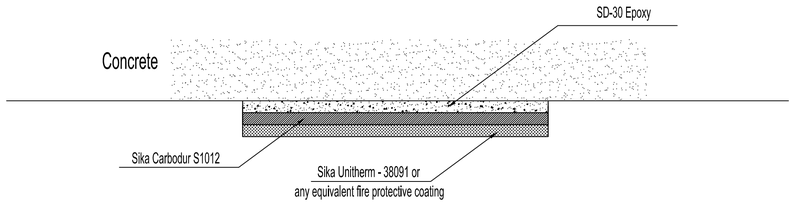

VIEW X (Exposed)

PINDAAN	TARIKH	CATITAN

TAJUK LUKISAN :

CADANGAN KERJA-KERJA MENGUKUH STRUKTUR LANTAI PUSAT DATA, ARAS 9, KE ATAS 1 BLOK (BLOK D - MENARA PEJABAT) YANG SEDIA ADA DI ATAS LOT PT. 13 & 88, JALAN YAP KWAN SENG, SEKSYEN 44, WILAYAH PERSEKUTUAN KUALA LUMPUR.

UNTUK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN)

PEMILIK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN) LOT G-2 TINGKAT BAWAH WISMA CHASE PERDANA, OFF JALAN SEMANATAN, DAMANSARA HEIGHTS, 50490, KUALA LUMPUR

TANDATANGAN PEMILIK :

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TAJUK LUKISAN :

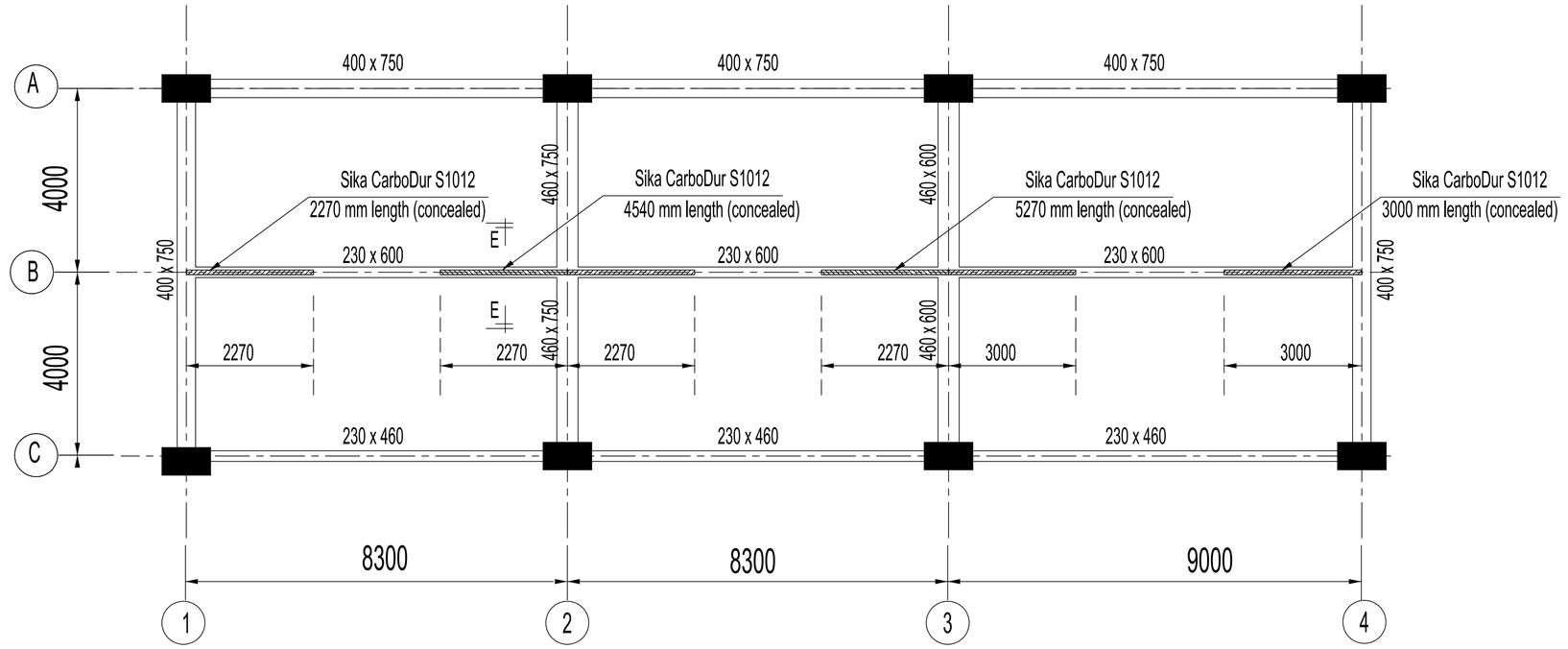
BOTTOM BEAM LAYOUT PLAN

- CFRP STRENGTHENING

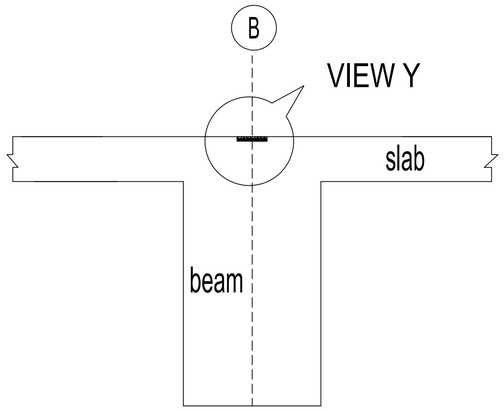
SKALA :	TARIKH : JANUARY 2015
DI R/BENTUK OLEH : AAM, SB & NH	DI SEMAK OLEH : IR .SALMIZI

NOMBOR LUKISAN :

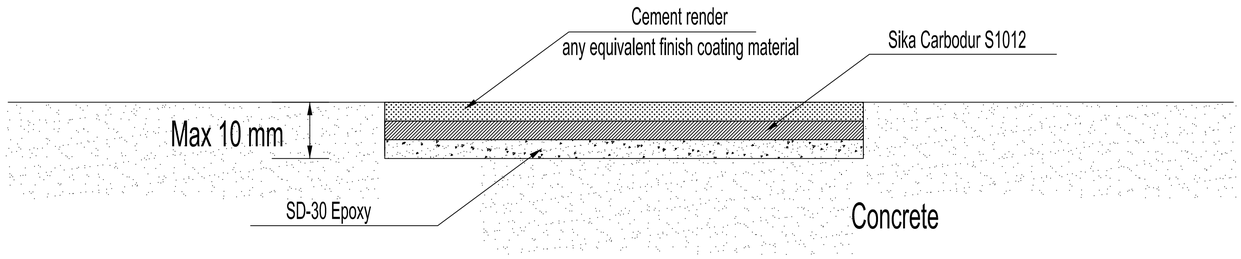
PTPTN/03/CFRP



TOP BEAM LAYOUT PLAN



SECTION E-E



VIEW Y (Concealed)

KONTRAKTOR HENDAKLAH MEMERIKSA SEMUA DIMENSI. HANYA DIMENSI YANG BERTULIS BOLEH DIGUNAKAN. SEBARANG KEMUSYKILAN HENDAKLAH DILAPORKAN KEPADA JURUTERA DENGAN SEGERA SEBELUM MEMULAKAN KERJA.

PINDAAN	TARIKH	CATITAN

TAJUK LUKISAN :

CADANGAN KERJA-KERJA MENGUKUH STRUKTUR LANTAI PUSAT DATA, ARAS 9, KE ATAS 1 BLOK (BLOK D - MENARA PEJABAT) YANG SEDIA ADA DI ATAS LOT PT. 13 & 88, JALAN YAP KWAN SENG, SEKSYEN 44, WILAYAH PERSEKUTUAN KUALA LUMPUR.

UNTUK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN)

PEMILIK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN) LOT G-2 TINGKAT BAWAH WISMA CHASE PERDANA, OFF JALAN SEMANATAN, DAMANSARA HEIGHTS, 50490, KUALA LUMPUR

TANDATANGAN PEMILIK :

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TAJUK LUKISAN :

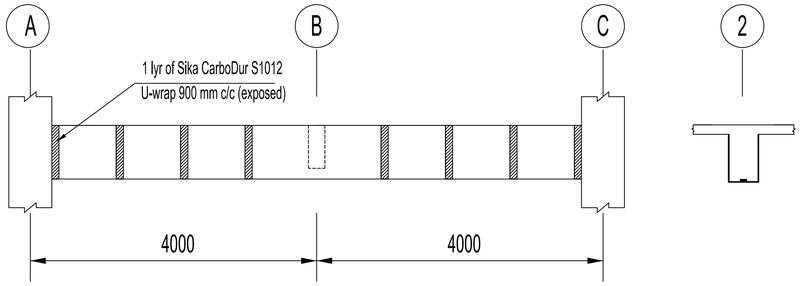
TOP BEAM LAYOUT PLAN

- CFRP STRENGTHENING

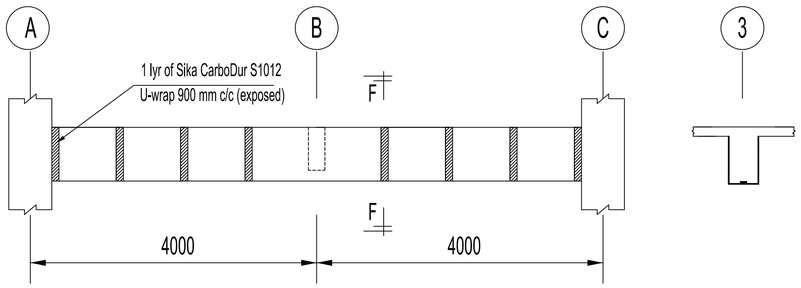
SKALA : 1 = 100	TARIKH : JANUARY 2015
DI R/BENTUK OLEH : AAM, SB & NH	DI SEMAK OLEH : IR .SALMIZI

NOMBOR LUKISAN :

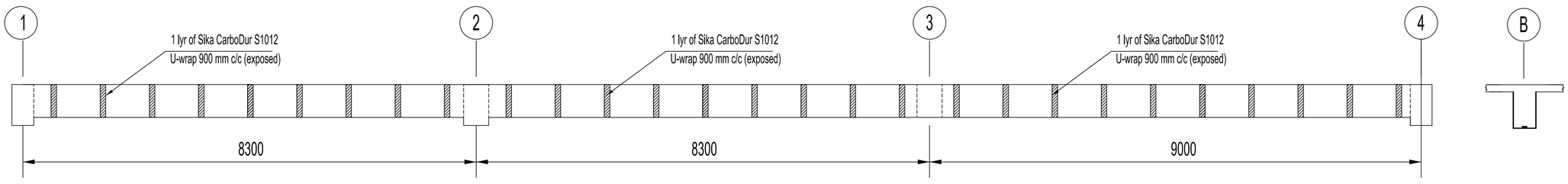
PTPTN/04/CFRP



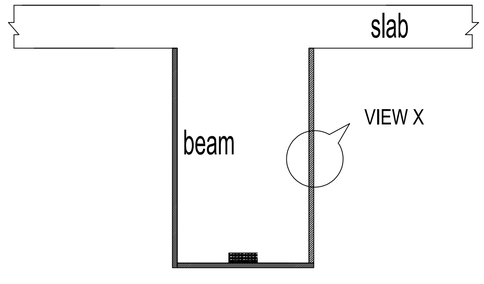
BEAM 2/A-C



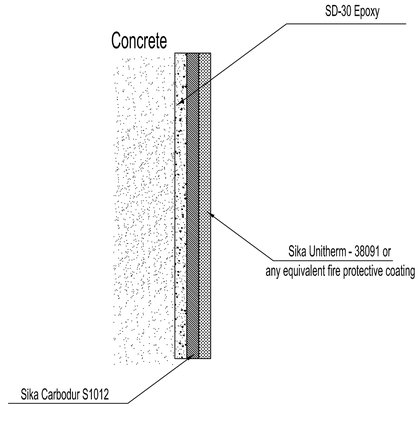
BEAM 3/A-C



BEAM B/1-4



SECTION F-F



VIEW X (Exposed)

PINDAAN	TARIKH	CATITAN

TAJUK LUKISAN :

CADANGAN KERJA-KERJA MENGUKUH STRUKTUR LANTAI PUSAT DATA, ARAS 9, KE ATAS 1 BLOK (BLOK D - MENARA PEJABAT) YANG SEDIA ADA DI ATAS LOT PT. 13 & 88, JALAN YAP KWAN SENG, SEKSYEN 44, WILAYAH PERSEKUTUAN KUALA LUMPUR.

UNTUK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN)

PEMILIK :

PERBADANAN TABUNG PENDIDIKAN TINGGI NASIONAL (PTPTN) LOT G-2 TINGKAT BAWAH WISMA CHASE PERDANA, OFF JALAN SEMANATAN, DAMANSARA HEIGHTS, 50490, KUALA LUMPUR

TANDATANGAN PEMILIK :

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TAJUK LUKISAN :

BEAM SHEAR CFRP DETAILS

- CFRP STRENGTHENING

SKALA :	TARIKH : JANUARY 2015
DI R/BENTUK OLEH : AAM, SB & NH	DI SEMAK OLEH : IR .SALMIZI

NOMBOR LUKISAN :

PTPTN/05/CFRP