VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
BRNO UNIVERSITY OF TECHNOLOGY

FAKULTA STAVEBNÍ
ÚSTAV BETONOVÝCH A ZDĚNÝCH KONSTRUKCÍ

FACULTY OF CIVIL ENGINEERING
INSTITUTE OF CONCRETE AND MASONRY STRUCTURES

KŘÍŽEM VYZTUŽENÁ PŘEDPJATÁ STROPNÍ DESKA

THE TWO WAY PRESTRESSED FLOOR SLAB

BAKALÁŘSKÁ PRÁCE
BACHELOR'S THESIS

AUTOR PRÁCE MARTIN PRÁŠEK
AUTHOR

VEDOUCÍ PRÁCE doc. Ing. LADISLAV KLUSÁČEK, CSc.
SUPERVISOR

BRNO 2016

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
FAKULTA STAVEBNÍ

Studijní program	B3607 Stavební inženýrství
Typ studijního programu	Bakalářský studijní program s prezenční formou studia
Studijní obor	3608R001 Pozemní stavby
Pracoviště	Ústav betonových a zděných konstrukcí

ZADÁNÍ BAKALÁŘSKÉ PRÁCE

Student	Martin Prášek
Název	Křížem vyztužená předpjatá stropní deska
Vedoucí bakalářské práce	doc. Ing. Ladislav Klusáček, CSc.
Datum zadání bakalářské práce	30. 11. 2015
Datum odevzdání bakalářské práce	27. 5. 2016

V Brně dne 30. 11. 2015

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ fakulta stavební DĚKANÁT - 1 -

n.z. ....
prof. RNDr. Ing. Petr Štěpánek, CSc.
Vedoucí ústavu

n.a. ....
prof. Ing. Rostislav Drochytka, CSc., MBA
Děkan Fakulty stavební VUT

Podklady a literatura

ČSN EN 1992
- podkladové výkresy konstrukce
- časopis Beton TKS
- odborná literatura podle doporučení vedoucího práce

Zásady pro vypracování (zadání, cíle práce, požadované výstupy)

- návrh konstrukce železobetonové a předpjaté
- ověření ULS a SLS navržené konstrukce
- výpočet pomocí software zkontrolovat zjednodušeně,
- porovnat získaná řešení

Požadované výstupy:
A) Textová část
A1) Technická zpráva
A2) Průvodní zpráva statickým výpočtem
B) Netextová část (resp. Přílohy textové části)
B1) Použité podklady,
B2) Statický výpočet,
B3) Přehledná grafická dokumentace získaných výsledků
B4) Výkresová dokumentace řešené konstrukce v rozsahu dle vedoucího práce

Struktura bakalářské/diplomové práce

VŠKP vypracujte a rozčleňte podle dále uvedené struktury:

1. Textová část VŠKP zpracovaná podle Směrnice rektora "Úprava, odevzdávání, zveřejňování a uchovávání vysokoškolských kvalifikačních prací" a Směrnice děkana "Úprava, odevzdávání, zveřejňování a uchovávání vysokoškolských kvalifikačních prací na FAST VUT" (povinná součást VŠKP).
2. Přílohy textové části VŠKP zpracované podle Směrnice rektora "Úprava, odevzdávání, zveřejňování a uchovávání vysokoškolských kvalifikačních prací" a Směrnice děkana "Úprava, odevzdávání, zveřejňování a uchovávání vysokoškolských kvalifikačních prací na FAST VUT" (nepovinná součást VŠKP v případě, že přílohy nejsou součástí textové části VŠKP, ale textovou část doplňují).

....
doc. Ing. Ladislav Klusáček, CSc.
Vedoucí bakalářské práce

ABSTRAKT

Bakalářská práce se zaměřuje na návrh a popouzení předpjaté stropní konstrukce víceúčelové budovy. Navrhovaná stropní konstrukce bude využívána jako kancelářské prostory. Při návrhu byla použita metoda vyrovnání zatížení od vlastní tíhy. Výsledkem je posudek navrhované konstrukce na mezní stav únosnosti, mezní stav použitelnosti a výkresová dokumentace.

PREFACE

This bachelor's thesis focuses on design and check of pre-stress concrete slab of multifunctional building. Designed floor slab is purposed as office spaces. Method of preliminary design was established as method balancing self-weight load. The result is check of designed structure on service limit state, ultimate limit state and drawings.

KLÍČOVÁ SLOVA

Předpjatá betonová deska, stropní deska se skrytými průvlaky, VSL, protlačení, ČSN EN 1992-1-1, MSP, MSÚ

KEY WORDS

Pre-stressed concrete slab, floor slab with hidden girder, VSL, punching, ČSN EN 1992-1-1, ULS, SLS

Bibliografická citace

Martin Prášek *Křížem vyztužená předpjatá stropní deska.* Brno, 2016. XX s., YY s. příl. Bakalářská práce. Vysoké učení technické v Brně, Fakulta stavební, Ústav betonových a zděných konstrukcí. Vedoucí práce doc. Ing. Ladislav Klusáček, CSc.

PROHLÁŠENÍ:

Prohlašuji, že jsem bakalářskou práci zpracoval samostatně a že jsem uvedl všechny použité informační zdroje.

V Brně dne 27. 5. 2016

....

podpis autora

Martin Prášek

Poděkování.

Chtěl bych poděkovat panu doc. Ing. Ladislavu Klusáčkovi, CSc. za odborné vedení, cenné rady a trpělivost při zpracovávání této bakalářské práce.

Také bych chtěl poděkovat za pomoc a užitečné rady panu Ing. Jiřímu Nemravovi.

CONTENT

INTRODUCTION **10**

1 CHARACTERISTICS OF THE BUILDING **11**

1.1 GENERAL INFORMATIONS 11

1.2 LOAD-BEARING STRUCTURE 11

12

1.3 BUILDING ENVELOPE 12

1.4 FLOOR ASSEMBLY 12

1.5 INTERNAL WALLS 13

2 MATERIALS **13**

3 CONSTRUCTION PROCESS **13**

3.1 ARMOURING 13

3.2 CONCRETING 14

3.3 POST-TENSIONING 16

3.4 ALLOWABLE LOAD 17

4 LOADS **17**

4.1 PERMANENT LOAD 17

4.1.1 SELF WEIGHT 17

4.1.2 OTHER PERMANENT LOADS 18

4.2 LIVE LOADS 18

4.3 TOTAL LOADS 19

4.4 LOAD CASE COMBINATIONS 19

4.4.1 ULTIMATE LIMIT STATE 19

4.4.1.1 DESIGN COMBINATION 19

4.4.2 SERVICE LIMIT STATE 20

4.4.2.1 CHARACTERISTIC COMBINATION 20

4.4.2.2 QUASI-PERMANENT COMBINATION 20

4.4.2.3 FREQUENTED COMBINATION 20

5 STRUCTURAL DESIGN **21**

5.1 PRE-STRESS DESIGN 21

5.2 PRELIMINARY DESIGN 21

5.3 CHECKS 25
5.3.1 CHECKS OF ULTIMATE LIMIT STATE 25
5.3.2 CHECKS OF SERVICE LIMIT STATE 26
5.3.3 CHECKS FOR PUNCHING 27

6 CONCLUSION 29

7 USED SOURCES 30

8 SEZNAM OBRÁZKŮ, TABULEK A GRAFŮ 31

ATTACHMENTS 32

INTRODUCTION

The aim of the bachelor’s thesis is design of two way pre-stressed concrete floor slab in first floor between axis C and F that will be used as office spaces.

For this reason was edited the plan of eight-storey multifunctional apartment building of rectangular plan on Turgeněvova street in Brno.

For load effects calculations was made 3D model in computational software SCIA Engineer. Structure was checked according ultimate limit state and service limit state. Drawings were made in software Allplan 2015 and AutoCAD 2013.

1 CHARACTERISTICS OF THE BUILDING

1.1 GENERAL INFORMATIONS

The building has dimensions of 56.55 x 13.1 m. The total height of the structure of the building is 24,190 above ± 0,000. The structure is designed as one expansion unit. The building foundations are designed as piles will be designed as a stand-alone without adjacent buildings.

1.2 LOAD-BEARING STRUCTURE

The load-bearing structure consists of cast-in-place concrete frame with two shear cores encasing an elevator shaft and staircase. Point supported floor structure is designed as a partially pre-stressed slab with hidden girders in column strip. Columns are designed to profile 550/400 mm and based on piles, which they are fixed to. Column dimension and position is unchanged in all levels. Cast-in-place rectangular slab is designed in all levels of thickness 230 mm. Span in the transverse direction is a maximum of 6.35 m and 8.0 m in the longitudinal direction. Floor slabs will be built with the top edge at the elevation of +3.230, +6.230, +9.230, +12.230, +15.230, +18.230, +21.230, +24.230. The shear cores are designed as cast-in-place wall thickness of 250 mm between the modular axes D x E-1-2 and K-L x 1 to 2. The walls are separated by working joints in the upper level of the each floor. Slabs and stair landings will be fixed into the wall of adjacent shear core. In walls of the core are made openings for doors and passageways.

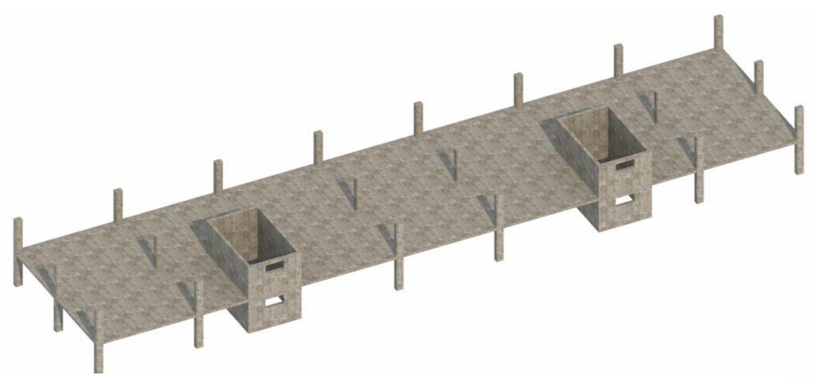

Figure 1 Floor

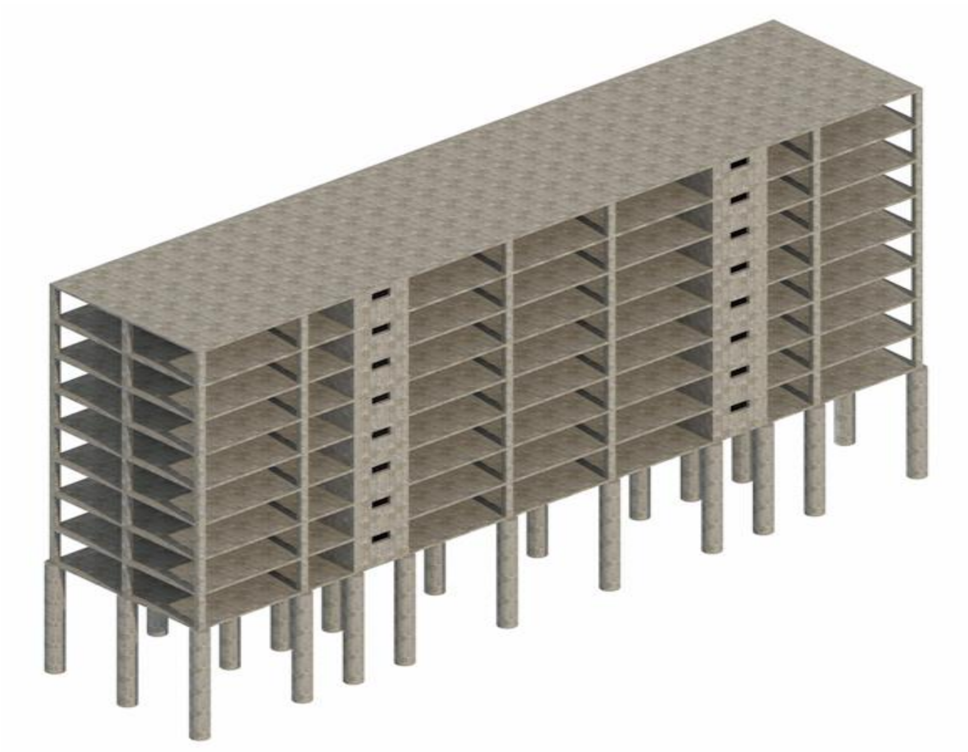

Figure 2 Axonometry

1.3 BUILDING ENVELOPE

Building envelope consists of external wall made of clay masonry Porotherm 250 P+D thickness of 250 mm. The structure of external wall will be insulated with contact thermal insulation.

1.4 FLOOR ASSEMBLY

Table 1 Floor finishes

FLOOR FINISHES	γ [kN/m³]	THICKNESS [m]
CERAMIC TILES	26,00	0,01
SCREED	23,00	0,05
IMPACT SOUND INSULATION	1,50	0,05
	Σ=	**0,11**

1.5 INTERNAL WALLS

Internal space is divided by portable plasterboard panel partition system RIGIPS.

Characteristic value of load is 0,8 kN/m^2

2 MATERIALS

Reinforcement of concrete structures: steel B500B

All concretes according to standard ČSN EN 206–1/Z3

Strength class of concrete:

Slab	- C30/37, XC1 (CZ, F.1) – Cl 0,4 – Dmax22 – S3
Columns	- C30/37, XC1 (CZ, F.1) – Cl 0,4 – Dmax22 – S3
Shear core	- C25/30, XC1 (CZ, F.1) – Cl 0,4 – Dmax22 – S3

3 CONSTRUCTION PROCESS

3.1 ARMOURING

Before rebar formwork must be properly checked if there are not impurities that could affect the quality of the concreting. During reinforcing should be a clearance of reinforcement that is described in the drawings. On all surfaces must be ensured the coverage of reinforcement by the placing spacers.

HDPE ducts are placed into form work together with other reinforcement before casting.

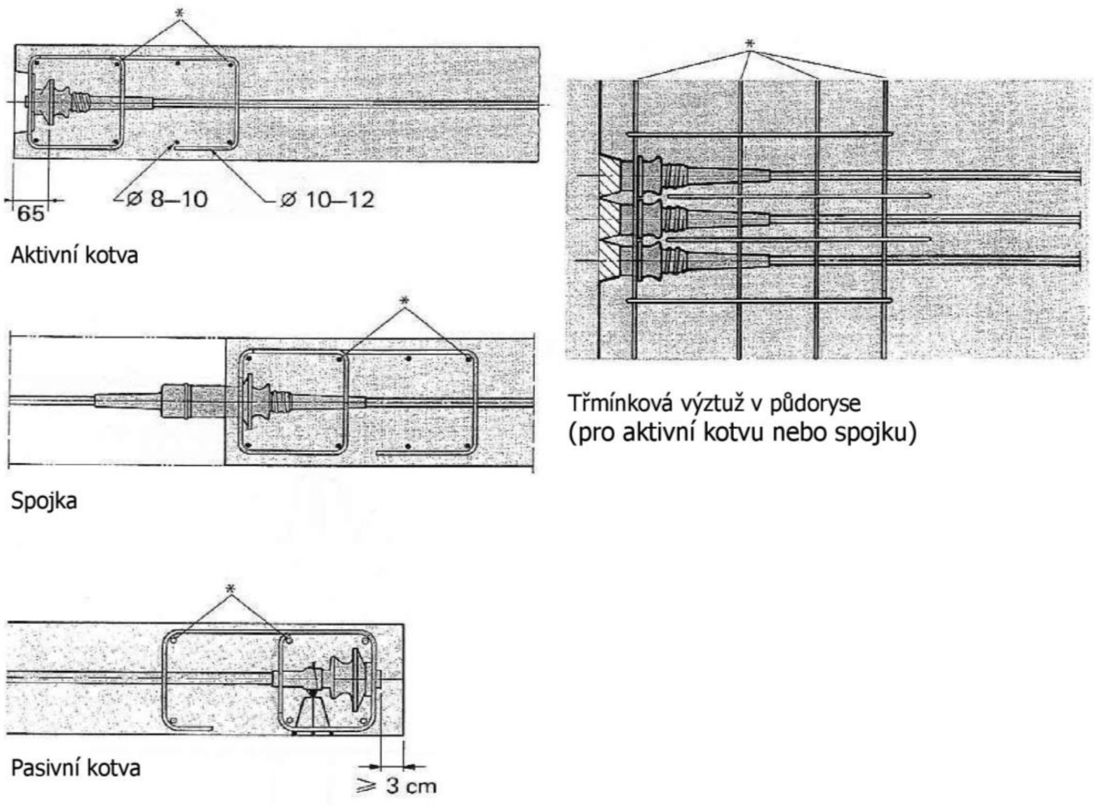

Figure 3 Detail of reinforcement - anchores

3.2 CONCRETING

It is ideal to do concreting at temperatures of 10°C to 25°C not during very strong wind and not on a direct sunlight. If the average temperature decrease below + 5°C the concreting must not be done without additional technological concrete adjustments.

Fresh concrete stored and compacted in formworks before it begins to solidify. Maximum transportation time for fresh concrete is 91min. If the delivery time is longer, it is necessary to use retarding additives.

The concrete mix should not be poured from a height higher than 1,5 m. Placement of more concrete layers on yet non-compacted layers is prohibited. Compaction will be performed with submersible vibrators which cannot touch the formworks during the dive.

Each batch of concrete mixture should be visually checked by the person responsible for quality. When there are suspicion about the quality appropriate control tests should be implemented. If the mixture does not meet set quality requirements shall not be used.

During concreting it is necessary to follow the valid standard ČSN EN 13670 implementation of concrete structures and also all the instructions of the manufacturer of concrete mix in addition to the guidelines above.

The fresh concrete must be cured for at least 12 hours; the recommended time is 7 days. Curing is performed by spraying water of approximately the same temperature as the temperature of the concrete surface. The surface of the concrete slabs should be protected by foil or moistened geotextile against direct sunlight, the wind or rain.

The slab formworks may be taken down the no sooner than 21 days after concreting and only in case of meeting the condition that the concrete has reached at least 70% of the prescribed strength. Strength test will be performed by using the Schmidt hammer type N.

3.3 POST-TENSIONING

Tensile elements are inserted into the structure before casting. In the structure are used active anchors S-6 and passive anchors SF-6

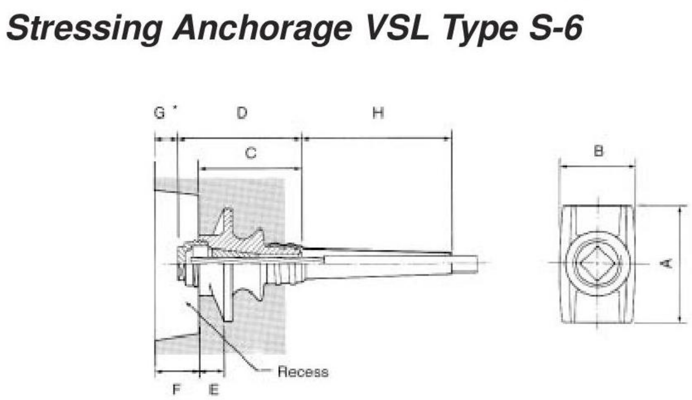

Figure 4 Active anchor type S-6

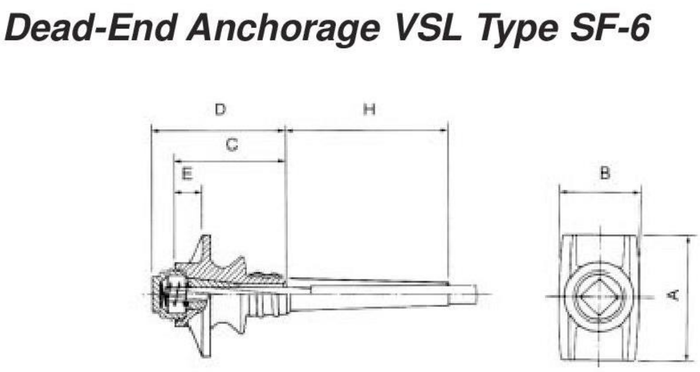

Figure 5 Pasive (dead-end) anchore type SF-6

After concreting will be the front of structure in areas of active anchors uncovered and the strand is fitted in the sleeve and wedges. Tensioning will be implemented ten days after concreting and be carried out by properly trained personnel under the supervision of specialists.

The strand is tensioned gradually in several steps, first the strands in the axis of the column, then those farther away from the axis.

3.4 ALLOWABLE LOAD

The construction can be loaded with the necessary building material not sooner than after 28 days or after reaching full strength anticipated. The maximum permissible load value is based on the service limit state, exactly on the limit state of cracking. Any excessive load, which is placed on the structure during the construction, must be consulted in advance with the author of the static calculation.

4 LOADS

4.1 PERMANENT LOAD

4.1.1 SELF WEIGHT

Table 2 Self weight load

CONCRETE SLAB	THICKNESS [mm]	γ [kN/m^3]	g_k [kN/m^2]
SELF WEIGHT	0,23	25	**5,75**
		$\Sigma g_{k=}$	**5,75**

4.1.2 OTHER PERMANENT LOADS

Table 3 Floor finishes load

FLOOR FINISHES	THICKNESS [m]	γ [kN/m^3]	g_k [kN/m^2]
CERAMIC TILES	0,01	26,00	0,26
SCREED	0,05	23,00	1,15
IMPACT SOUND INSULATION	0,05	1,50	0,08
		Σ g_k=	**1,49**

Table 4 External walls load

EXTERNAL WALLS	h [mm]	THICKNESS [m]	γ [kN/m^3]	g_k [kN/m]
POROTHERM 250 P+D	2,75	0,25	9,8	**6,74**
			Σg_k=	**6,74**

4.2 LIVE LOADS

Floor slab is on the whole surface loaded with characteristic load for buildings category B – office spaces - characteristic load value 3,0kN/m^2

Load of walls - characteristic value 0,8 kN/m^2

Table 5 Live loads

LIVE LOADS	q [kN/m^2]
LOAD OF WALLS	0,80
LIVE LOAD	3,00
Σq_k=	**3,80**

4.3 TOTAL LOADS

Table 6 Total loads

LIVE LOADS	g_k/q_k [kN/m^2]
SELF WEIGHT	5,75
FLOOR FINISHES	1,49
EXTERNAL WALLS	6,74
INTERNAL WALLS	0,80
LIVE LOAD	3,00

4.4 LOAD CASE COMBINATIONS

According standard ČSN EN 1990 we consider for calculating and checks of ultimate limit state with design combination of loads. For checks of service limit state we consider combination characteristic, quasi-permanent and often.

4.4.1 ULTIMATE LIMIT STATE

4.4.1.1 DESIGN COMBINATION

Equation 6.10a

$$\sum_{j\geq 1}\gamma_{G,j} G_{k,j} "+" \gamma_P P "+" \gamma_{Q,1} \psi_{0,1} Q_{k,1} "+" \sum_{i>1}\gamma_{Q,I} \psi_{0,i} Q_{k,i}$$

Equation 6.10 b

$$\sum_{j\geq 1}\xi_j \gamma_{G,j} G_{k,j} "+" \gamma_P P "+" \gamma_{Q,1} Q_{k,1} "+" \sum_{i>1}\gamma_{Q,I} \psi_{0,i} Q_{k,i}$$

Partial reliability coefficients:

– for permanent loads γG = 1,35

– for live loads γQ = 1,5

Combination coefficient of load:

Buildings category B: $\psi_0 = 0,7$

4.4.2 SERVICE LIMIT STATE

4.4.2.1 CHARACTERISTIC COMBINATION

Overall effects of all loads

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{0ji} Q_{k,l}$$

4.4.2.2 QUASI-PERMANENT COMBINATION

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} \sum_{i>1} \psi_{2,i} Q_{k,i}$$

4.4.2.3 FREQUENTED COMBINATION

Permanent loads and frequented live loads

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} \psi_{1,1} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{2i} Q_{k,i}$$

Combination coefficient of load:

Buildings category B: $\psi_1 = 0,5$; $\psi_2 = 0,3$

5 STRUCTURAL DESIGN

5.1 PRE-STRESS DESIGN

The load balancing method was used for the pre-stress tension design. This method provides longer durability and serviceability of the structure. Depending on required degree of pre-stressing it's recommended to balance 80 to 100% of self-weight loads. To evaluate the effect of pre-stressing, which we balance external loads with, is used equivalent load concept.

There were designed parabolic trajectories of strands that follow the diagram of bending moments caused by self-weight loads.

Pre-stressing tendons were designed according VSL systems, s.r.o. Pre-stressing bondless strands type monostrand Y1770-s-7. Diameter of strand 15,3 mm, area 140 mm^2

5.2 PRELIMINARY DESIGN

For design of prestressing force was necessary to calculate tension in steel reduced by short-term friction loss of pre-stress and and based on them established long-therm loss.

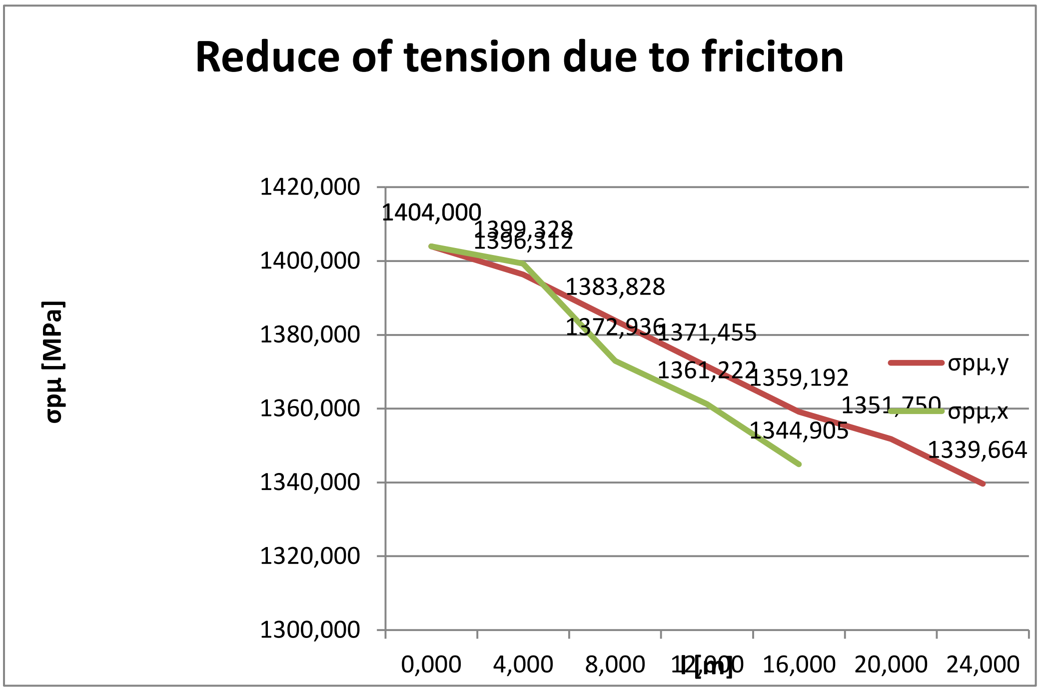

Chart 1 Friciton loss

Determination of slab thickness

$$\frac{l}{h} = 36$$

$$h = 230mm$$

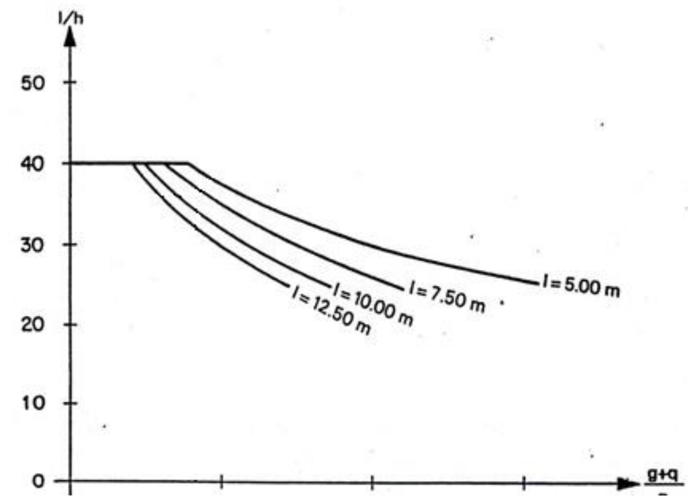

Figure 6 Ration of span to slab thickness

Determination of pre-stress

$$p = \frac{u \times l^2}{8 \times f} \text{ [kN/m]}$$

$\boldsymbol{P = p \times l}$ **[kN]**

Determination with the assistance of diagram in which the size of pre-stress are stated

$$\frac{g_k + q_k}{g_k}$$

$$\varkappa = \frac{h \times \sigma\mathrm{ct}}{l^2 \times \gamma_c}$$

$$\frac{u}{g_k} = 1{,}4$$

$$u = 1{,}4 \times g_k$$

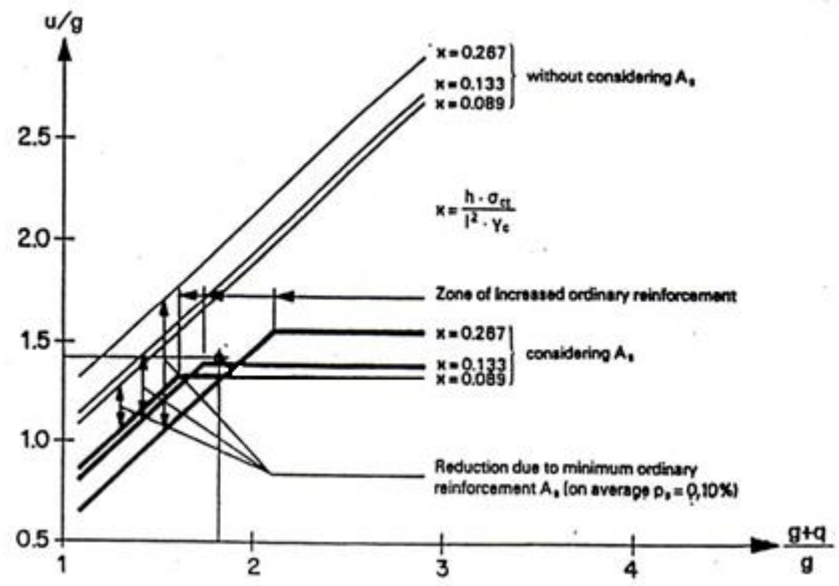

Figure 7 Ration of transverse component u from pre-stress to self-weight

Determination of pre-stress balancing self-weight load

$\boldsymbol{u = (0{,}8 \sim 1{,}0) g_k}$ **[KN/m²]**

Equivalent loads

The equivalent load expresses effects of the designed pre-stressing force on structure

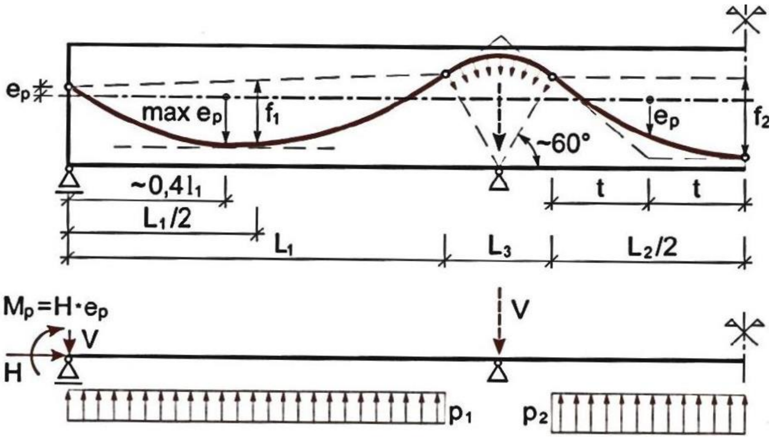

Figure 8 Equivalent load concept

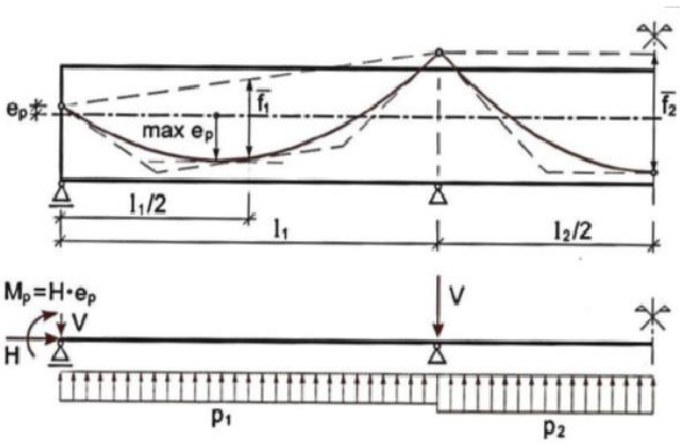

Figure 9 Equivalent load design

After successful design of required pre-stress we try design ideal number of strands to reach minimal vertical deformation in hidden girder when load combination of self-weight and pre-stress.

5.3 CHECKS

5.3.1 CHECKS OF ULTIMATE LIMIT STATE

The structure was checked on load combination 6.10b. All calculations are in attachemant B2) Statický posudek in chapter 7.1 Ultimate limit state, on page 19.

Check of required load-bearing capacity of bending moment and axis force above column, in girder cross section where the biggest bending moment is and in the span.

First we establish the preassure reserve $\Delta\sigma_{pt}$ which is for bondless strands 100 MPa. Than we determine force in prestressed steel ΔF_{pt}. This force will be placed into calculation of load-bearing capacity of bending moment.

$$\Delta F_{pt} = A_p \cdot \Delta\sigma_p$$

Calculation of neutral axis position

$$x_c = \frac{N_{Ed} + \Delta F_{pt}}{b \cdot f_{cd}};\ x = \frac{x_c}{\lambda}$$

Calculation of neutral axis continuous with calculation of moment o ultimate limit state and comparison to designed moment.

$$M_{Rd,p} = F_{cc} \cdot z_{cc} + \Delta F_{pt} \cdot z_{pt}$$
$$M_{Rd,p} \geq M_{Ed}$$

If condition is not satisfied we have to design the ordinary reinforcement on the bearing capacity of the remaining (diference) moment. In case that condition is satisfied we design jst minimal reinforcement.

$$A_{s,min} = 0{,}26 \cdot \frac{f_{ctm}}{f_{yk}} \cdot b \cdot d$$

$$M_{Rd,st} = z_{st} \cdot F_{st}$$

The result load-bearing capacity of cross-section is the sum of strength in tendon and in ordinary reinforcement.

$M_{Rd} = M_{Rd,st} + M_{Rd,p}$

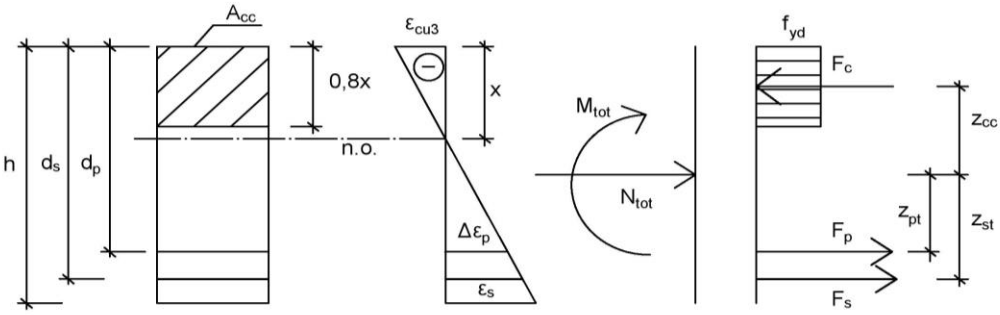

Figure 10 Ultimate limit state

5.3.2 CHECKS OF SERVICE LIMIT STATE

The concrete slab must be checkd on service limit state, that check the qualities of structure to long-term functionality.

Stress limitation

For post tensioned concrete structures is requirement that stress in compressed fibers of cross-section must not exceed limit 0,6xf_{ck} in characteristic load combination, 0,45xf_{ck} in quasi-permanent combination and concrete tensile streng f_{ctm}.

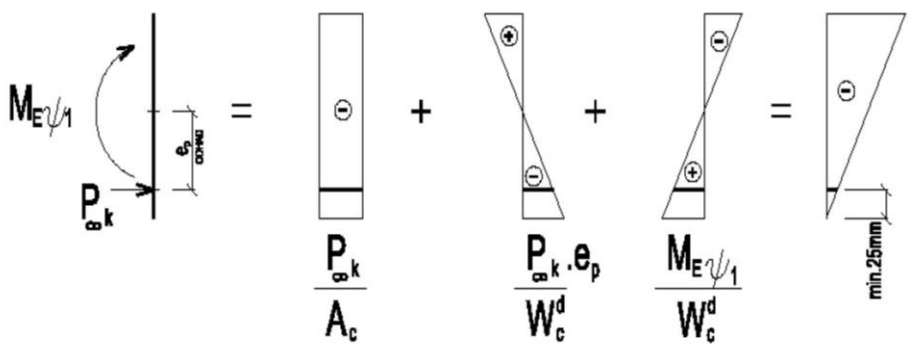

Figure 11 Stress in cross-section

Designed slab satisfied on all this conditions se there are not longitudinal either transverse cracks.

In the middle of girder forms tensile stress in top fibers. Girder top surface reinforcement was checked on top suprface moment of top surface fibers loading combination – self-weight and pre-stress.

Designed ordinary reinforcement satisfied conditions.

The structure was checked on characteristic and quasi-permanent load case combinations. All calculations are in attachemant B2) Statický posudek in chapter 7.2 Ultimate limit state, on page 37.

5.3.3 CHECKS FOR PUNCHING

Slab was checked for punching by the inner column that was loaded by shear force of combination 6.10b from which was deducted force of prestress that is carryied by column. Shear force was calculated in software. Results of calculations of inner forces are attached in B3).

All calculation of check for punching are in attachement B2) Statický posudek in chapter 7.3 Checks for punching

Coefficient β was considered 1,15

$$V_{Ed,1} = \beta \cdot \frac{V_{Ed}}{u_1 \cdot d}$$

$$V_{Rd,c} = C_{Rd,c} \cdot k \cdot (100 \cdot \rho_l \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp}$$

$$V_{Rd,c} \geq V_{Ed,1}$$

The structure satisfied on load of shear force, so there was designed minimal level of reinforcement. 12xØ10 Schöck BOLE

$$A_{sw,min} = \frac{0{,}08 \cdot \frac{\sqrt{f_{ck}}}{f_{yk}} \cdot s_r \cdot s_t}{1{,}5 \cdot \sin\alpha + \cos\alpha}$$

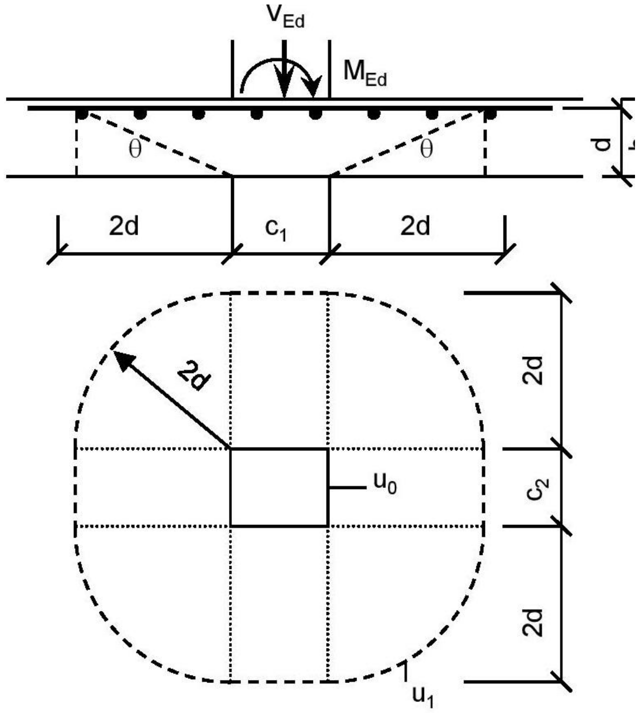

Figure 12Punching

6 CONCLUSION

The task of this bachelor’s thesis was design and checks of ultimate limit state and service limit state of prestressed concrete slab. It was compared preliminary design of prestress with assistance of design diagrams and by balancing equivalent loads on 80-100% of self-weight load.

By balancing of deflections on floor slab loaded in t_0 on combination of prestress nad self-weight in order to achieve as small deflections as possible we found out that preliminary design by using diarams is unreal and most suitabel is prestress equal to 80% of self weight.

In ultimate limit state and service limit state the slab achieved all the requirements with minimal ordinary reinforcement but proved itself to be oversized even on minimal recommended level of prestress so not appropiate for building of this dimensions and loads.

7 USED SOURCES

Zákony, vyhlášky, normy směrnice

1. NORMA ČSN ISO 1990-1-1 ZÁSADY NAVRHOVÁNÍ KONSTRUKCÍ. PRAHA: ČESKÝ NORMALIZAČNÍ INSTITUT, 2004.
2. NORMA ČSN EN 1992-1-1Navrhování betonovch konstrukcí: Obecná pravidla pro pozemní stavby. Praha: Český normalizační institut,2005
3. ČSN EN 1991-1 Zatížení stavebních konstrukcí. Praha: Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2004

Elektronické zdroje

4. *http://www.vsl.cz*
5. *http*://www.fce.vutbr.cz/BZK/lanikova.i/CL01/CL01.htm

Odborné publikace

6. NAVRÁTIL, J. PŘEDpjaté betonové konstrukce. Akademické nakladatelství CERM, s.r.o. Brno 2008
7. Kolektiv autorů, Navrhování betonových konstrukcí. Příručka k ČSN EN1992-1-1 a k ČSN EN1992-1-2, Informační centrum ČKAIT, s.r.o., Sokolská 15, Praha 2
8. Navrátil, J.; Zich; M. Předpjatý beton, Modul P01, Průvodce předmětem BL11. Brno, 2006

8 SEZNAM OBRÁZKŮ, TABULEK A GRAFŮ

Figures

Figure 1 Floor 11
Figure 2 Axonometry..........12
Figure 3 Detail of reinforcement - anchores..........14
Figure 4 Active anchor type S-6 16
Figure 5 Pasive (dead-end) anchore type SF-6..........16
Figure 6 Ration of span to slab thickness..........22
Figure 7 Ration of transverse component u from pre-stress to self-weight..........23
Figure 8 Equivalent load concept..........24
Figure 9 Equivalent load design 24
Figure 10 Ultimate limit state 26
Figure 11 Stress in cross-section..........26
Figure 12Punching..........28

Tables

Table 1 Floor finishes 12
Table 2 Self weight load 17
Table 3 Floor finishes load 18
Table 4 External walls load..........18
Table 5 Live loads..........18
Table 6 Total loads 19

Charts

Chart 1 Friciton loss..........22

ATTACHMENTS

Attachment B.1	Sources, materials
Attachment B.2	Structural design
Attachment B.3	Calculations results
Attachment B.4	Drawings

PROHLÁŠENÍ O SHODĚ LISTINNÉ A ELEKTRONICKÉ FORMY VŠKP

Prohlašuji, že elektronická forma odevzdané typ práce je shodná s odevzdanou listinnou formou.

V Brně dne 27. 5. 2016

Martin Prášek